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IBM System/360 System Summary

This publication provides basic information about the IBM System/360; its objective is to help readers achieve a general understanding of this data processing system and of the interrelationships of its models and components. Briefly discussed are the system concepts, the features, the individual models, the programming systems, and the attachable input/output devices.

It is assumed that the reader has a basic knowledge of data processing systems, as given in *Introduction to IBM Data Processing Systems*, Form C20-1684.

More detailed information about System/360 is available in *IBM System/360 Principles of Operation*, Form A22-6821. Publications further describing the individual System/360 models, programming systems, input/output devices, and teleprocessing equipment are listed in *IBM System/360 Bibliography*, Form A22-6822, and *IBM Teleprocessing Bibliography*, Form A24-3089.

This publication does not apply to System/360 Model 20. All Model 20 publications are listed in the *IBM System/360 Model 20 Bibliography*, Form A26-3565.

ELEVENTH EDITION (August, 1969)

This major revision obsoletes A22-6810-9 and Technical Newsletters N22-0319, N22-0323, and N22-0332. The manual has been reorganized and partly rewritten to permit easier use and understanding. Several input/output device descriptions have been extensively revised, and a few new ones have been added. New input/output devices included in this revision are the IBM 1288 Optical Reader and the IBM 2260 Display Station Model 2 with the IBM 2848 Display Control Models 21 and 22. Other changes to the text are indicated by a vertical line to the left of the change. Where a complete section has been added or revised, the symbol (•) appears to the left of the heading. Changed or added illustrations are denoted by the symbol • to the left of the caption.

Changes are periodically made to the specifications herein; before using this publication in connection with the operation of IBM systems, refer to the latest System/360 SRL Newsletter, Form N20-3060, for the editions that are applicable and current.

Requests for copies of IBM publications should be made to your IBM representative or to the IBM branch office serving your locality.

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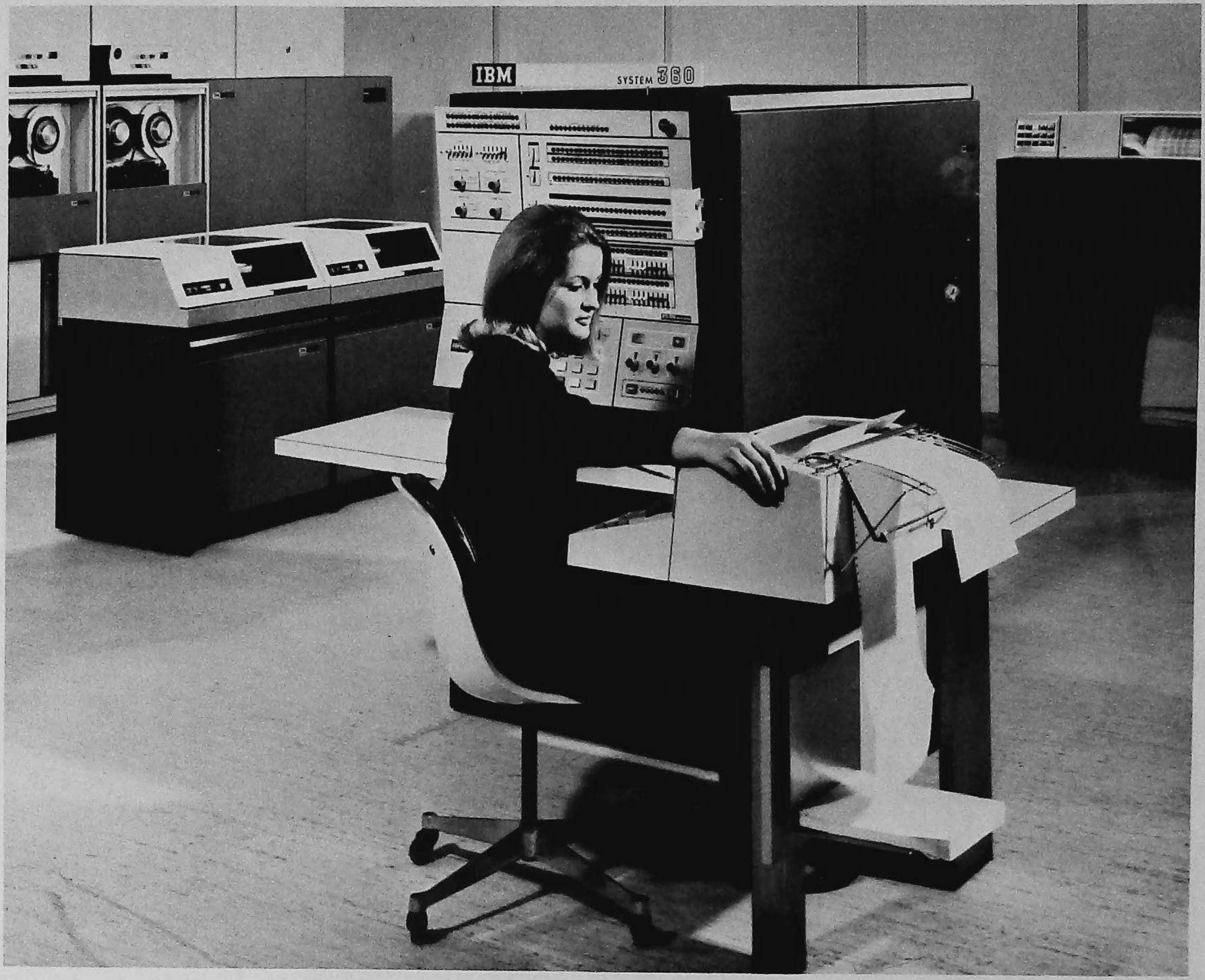


IBM System/360 Model 40

• Section 1. Introduction to IBM System/360

IBM System/360 provides a wide range of computing versatility and power combined with exceptional reliability and efficiency. The different models within System/360 are identical in concept and compatible in programming, but are scaled in size, speed, and cost to fit the needs of different users. The many ways System/360 meets these needs are discussed in the following paragraphs.

System/360 is a general-purpose system. System/360 can be tailored for a wide variety of applications:

1. Commercial applications, which require decimal arithmetic, variable-length fields, and editing capabilities.
2. Scientific applications, which require larger storage capacities and high-speed binary arithmetic.
3. Communications, which often requires a large number of communication terminals and fast response.
4. Control applications, which require fast internal processing speeds and high reliability.
5. Any combination of the preceding applications.

System/360's design is open-ended. This permits System/360 to easily expand and to incorporate new features, devices, and technology. One example is the system's capability of addressing over 16 million bytes of main storage, thereby anticipating larger storage needs than those already met. Another example is the use of an eight-bit character code that allows for as many as 256 characters, permitting easy code expansion for future needs.

System/360 offers a wide choice of models, each with an extensive selection of facilities. The different models offer users a choice of performance ranges. Each model also has a wide selection of main storage capacities, I/O devices, programming support, and features, permitting the system to be tailored to the user's needs. As his needs change, his system can often be modified correspondingly.

System/360 offers system compatibility. When expansion of data processing operations requires a larger model of System/360, system compatibility ensures easy transition. This characteristic permits programs that operate on one model of System/360 to operate on other models that have the necessary configuration and features.

Transition to System/360 from most other IBM systems is facilitated by the compatibility features, which are combinations of circuitry and programming that enable System/360 to execute programs written for other IBM systems. In many cases, the programs are executed faster on the System/360 than on the system for which they were written.

System/360 has self-supervision capabilities. This is due primarily to the System/360 interruption system and to the control programs. The *interruption system* permits the central processing unit (CPU) to:

1. Quickly change state as a result of conditions in the CPU itself, in the input/output (I/O) units, or external to the system.
2. Identify the type of interruption.
3. Store the current status information to permit later resetting of the status that the CPU had before the interruption.

The interruption system operates in conjunction with a *control program.* System/360 models are designed to operate with a control program, an integral part of most System/360 programming systems. With a control program:

1. Data and programs processed by System/360 are systematically organized, identified, stored, and retrieved.
2. A continuous series of jobs can be performed by System/360 with little or no operator intervention.
3. Several data processing tasks can be performed concurrently, thereby increasing the total throughput of System/360.

System/360 permits easy attachment of many different I/O devices that can operate concurrently with data processing. To overlap data processing and I/O operations efficiently, System/360 uses channels; these units relieve the central processing unit of the direct handling of I/O operations. One type of channel (the selector channel) is used primarily to control high-speed I/O devices, such as magnetic tape units and disk storage units; another type (the multiplexer channel) simultaneously controls a number of lower-speed devices, such as communication terminals, printers, and punched-card devices. The channels operate through the System/360 I/O interface, which provides the system with a uniform method of easily attaching many different I/O devices. Both the channels and the I/O interface facilitate the attachment of new I/O devices, developed to meet the needs of users.

System/360 offers high reliability. This is done by using more reliable components and circuits, parity checking, error-checking and correction circuitry, the System/360 interruption system, instruction retry, and system compatibility.

The reliability of System/360 is significantly higher than that of its predecessors because of the reliability of its basic component circuitry, which may be solid logic technology (SLT) or any of the more advanced circuit technologies. Parity checking, used on all models of System/360, increases reliability by monitoring both data and instructions for invalid information. On some models, parity checking is complemented by error-checking and correction circuitry. Error checking is also done during program execution by the interruption system, clearly separating interruptions caused by either machine or programming errors, thus helping to minimize downtime. Systems equipped with the instruction retry feature automatically attempt to re-execute failing instructions, thereby reducing the possibility of program interruption. System compatibility contributes to reliability by permitting the coupling of units to form a system that is operational even though some components may fail.

• Section 2. System/360 Basic Structure

The basic structure of a System/360 model (Figure 2-1) consists of main storage, a central processing unit (CPU), one or more channels, and input/output devices attached to the channels through control units, and the System/360 I/O interface.

Data Formats

The system transmits data between main storage and CPU in multiples of eight bits. Each eight-bit unit of data is called a *byte,* the basic building block of all formats in System/360. A ninth bit, the *parity* or *check* bit, is transmitted with each byte and carries odd parity in the byte. The parity bit cannot be affected by the program; its only purpose is to cause an interruption when a parity error is detected. In this manual, references to data exclude the mention of the associated parity bits.

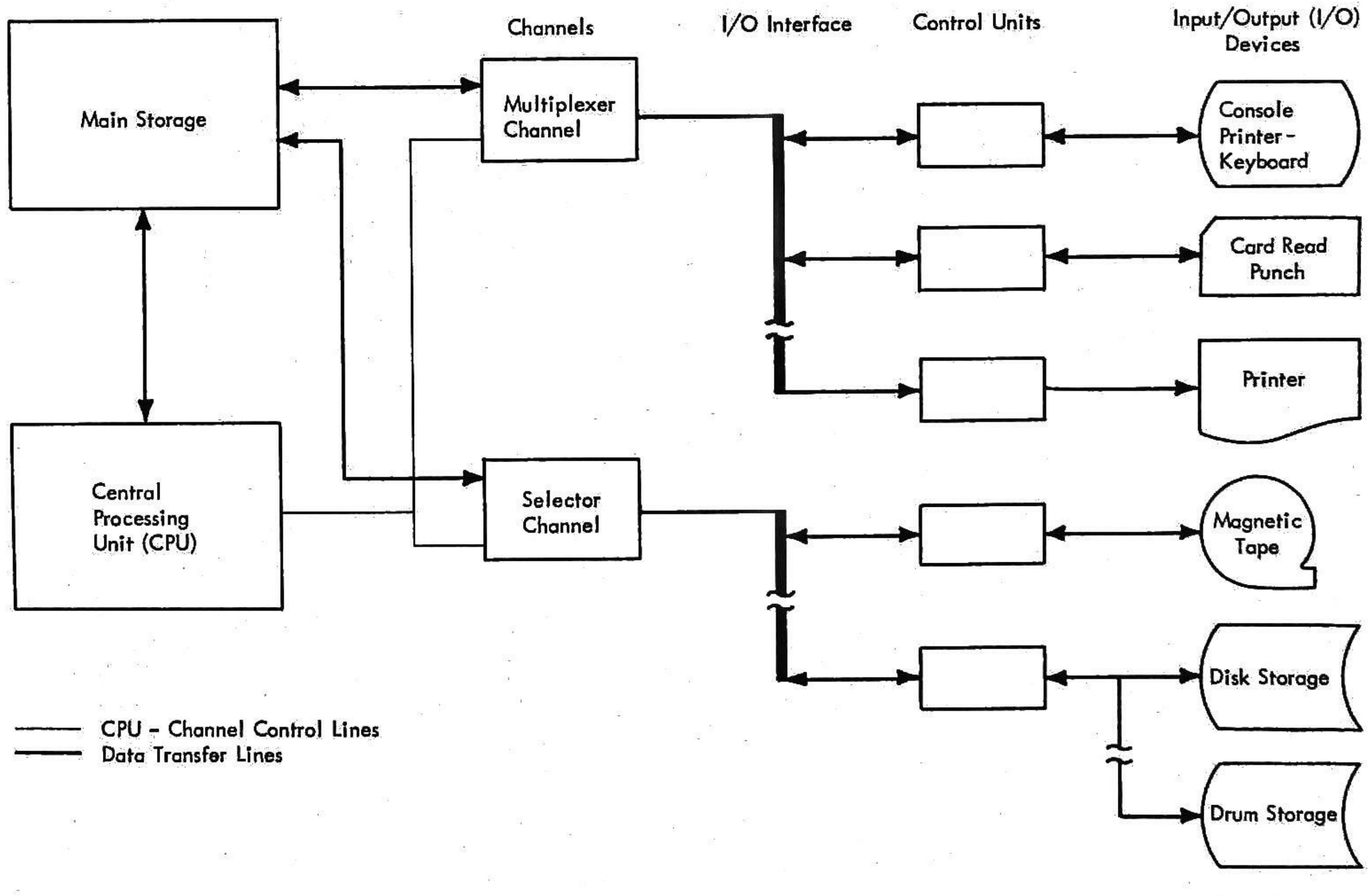
Bytes may be handled separately, or they may be grouped in *fields.* The *halfword, word,* and *doubleword* are fields of consecutive bytes; a halfword has two bytes, a word has four bytes, and the doubleword has eight bytes. These fields make up the basic fixed-length data formats (Figure 2-2).

Data formats are either fixed-length or variable-length. During processing, their field length is either implied by the operation to be performed or it is stated explicitly as part of the instruction.

Data Representation

In System/360, data (whether numeric, alphabetic, or alphameric) is processed in multiples of an eight-bit byte. The data may be in binary form (as numeric data for most scientific computations) or it may be in a binary *code.* Coding permits data to be represented by characters (for example, 1, 2, A, B, and *) on devices such as card readers, visual display units, and printers. These devices are code-dependent; that is, their operation depends on the code used to represent the characters.

The eight-bit byte provides for as many as 256 characters, which allows for future code expansion and permits System/360 to accept most present and future



• Figure 2-1. Organization of a Representative System/360 Model

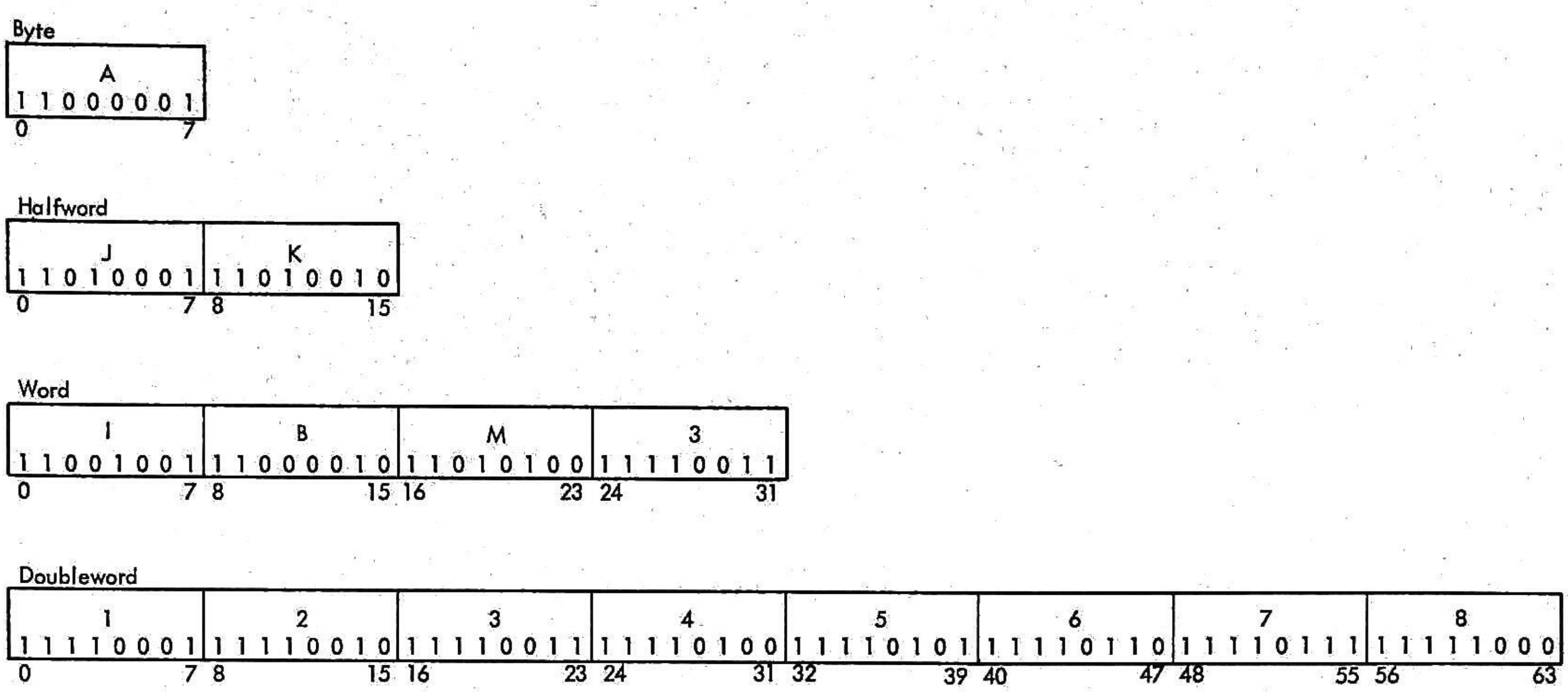


Figure 2-2. Basic Fixed-Length Data Formats (with EBCDIC-Coded Data)

codes. The most commonly used character code in System/360 is the extended binary-coded-decimal interchange code (EBCDIC). The bit positions in EBCDIC (Figure 2-3) are numbered the same as those of bytes (left to right, 0-7). Another code that may be used in place of EBCDIC is the USA Standard Code for Information Interchange (USASCII) extended to eight bits, in this manual referred to as USASCII-8.

Main Storage

Main storage, housed with the CPU in the smaller models and housed separately in the larger ones, provides the system with directly-addressable fast-access storage of data. Both data and programs must be loaded into main storage (from input devices) before they can be processed.

EBCDIC Bit Order
01234567

Bit Positions 0123 / Bit Positions 4567

	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000																
0001																
0010																
0011																
0100	Blank										¢	.	<	(	+	|
0101	&										!	$	*	)	;	¬
0110	-											,	%	_	>	?
0111											:	#	@	'	=	"
1000		a	b	c	d	e	f	g	h	i						
1001		j	k	l	m	n	o	p	q	r						
1010			s	t	u	v	w	x	y	z						
1111																
1100		A	B	C	D	E	F	G	H	I						
1101		J	K	L	M	N	O	P	Q	R						
1110			S	T	U	V	W	X	Y	Z						
1111	0	1	2	3	4	5	6	7	8	9						

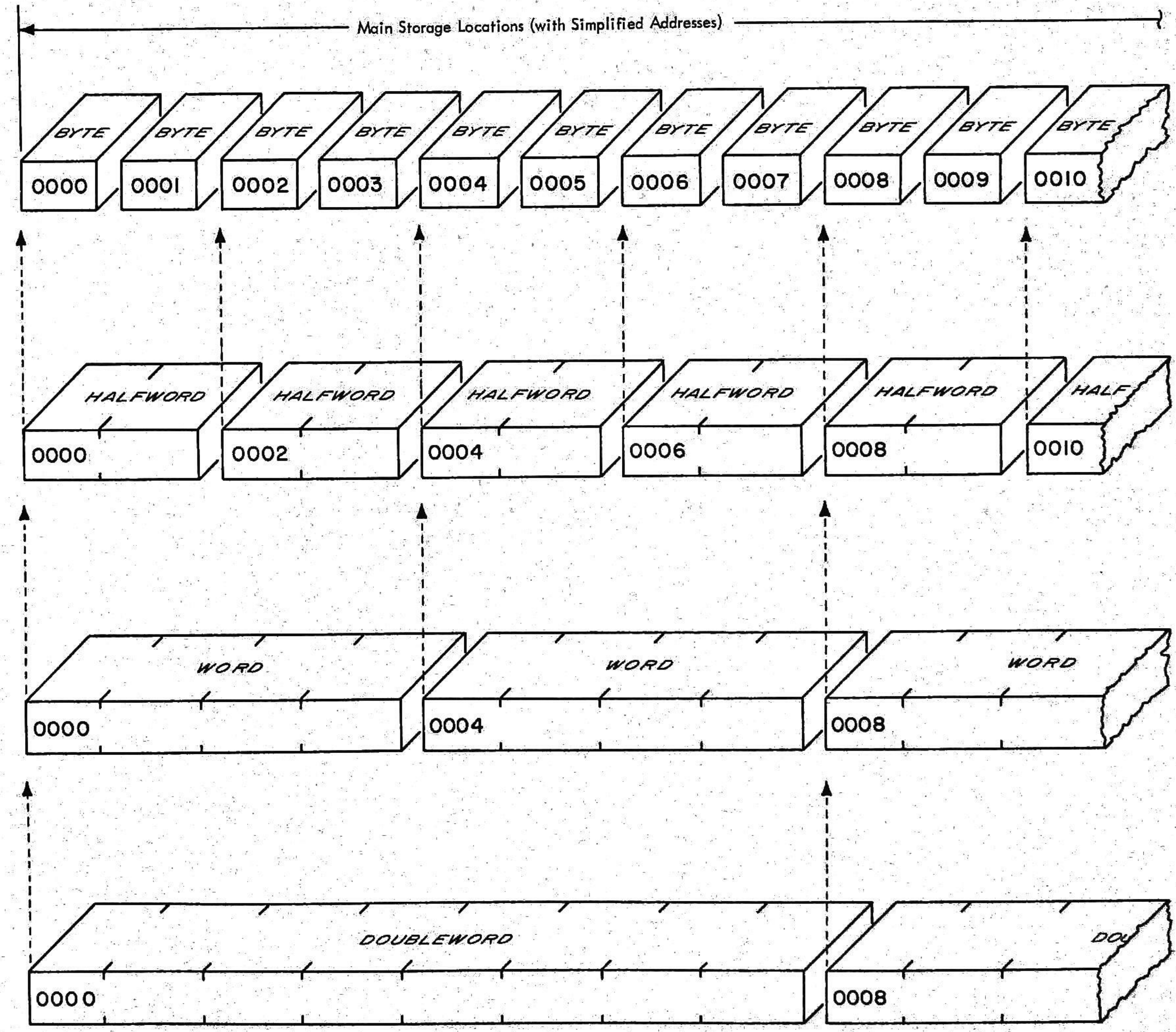
● Figure 2-3. EBCDIC Character Codes (Excluding Control Character Representations)

Addressing

Byte locations in main storage are consecutively numbered starting with 0; each number is the address of the corresponding byte. A group of bytes in storage is addressed by the leftmost byte of the group. The number of bytes in the group is either implied by the instruction format or explicitly defined by the instruction itself. Anticipating future storage needs, the addressing arrangement uses a 24-bit binary address, which gives System/360 the capability of addressing as many as 16,777,216 bytes of storage. This set of main-storage addresses includes some locations reserved for special purposes.

Data Positioning

Restrictions on the positioning of data in storage depend on whether a data field is variable- or fixed-length. *Variable*-length fields may start on any byte location, but *fixed*-length fields (such as halfwords, words, and doublewords) in most models must be located in main storage on *integral boundaries.* A boundary is integral for a unit of data when its main storage address is a multiple of that unit's length in bytes. For example, halfwords (two bytes) must have main storage addresses that are multiples of two. Figure 2-4 shows integral boundaries for the common units of data, showing simplified addresses (of main



● Figure 2-4. Representative Integral Boundaries for Halfwords, Words, and Doublewords in Main Storage

storage) as four-digit decimal numbers (0000, 0001, 0002, etc.) rather than the 24-digit binary numbers actually used. Sequential halfword addresses are shown in Figure 2-4 as 0000, 0002, 0004, etc. Words (four bytes) must have addresses that are multiples of four (shown in Figure 2-4 as 0000, 0004, 0008, etc.). Doublewords (eight bytes) must have addresses that are multiples of eight (shown in Figure 2-4 as 0000, 0008, 0016, etc.).

For exception to the boundary restriction, see "Byte-Oriented Operand" discussed in Section 3.

Performance Factors

The variety of main-storage units available for the System/360 models permits the system to be tailored to suit the individual needs of the user. The units differ in capacities, access widths, cycle times, and degrees of interleaving.

Depending on the model, storage capacities range from 8K (8,192) bytes to 6,144K (6,291,456) bytes. (In this manual, 1K = 1024.) Additional directly-addressable storage is available for several models, permitting main storage increases (in round numbers) of one to eight million bytes.

Storage Access Width is the number of bytes fetched in each main-storage access. As access width increases, the quantity of data that may be processed per unit time increases. The width, which is model-dependent, ranges from 1 to 16 bytes.

Storage Cycle Time is a measure of storage speed and is defined as the length of time that main storage is busy whenever a reference is made to it. The shorter the cycle time, the greater the number of operations that can be performed in any time interval. Fixed for each model, this cycle time ranges from 0.75 to 2.5 microseconds.

Storage interleaving, available with the larger System/360 models, increases the number of main-storage accesses started in a storage cycle, thereby significantly increasing the amount of data accessed per unit time. With interleaving, the number of accesses started during a storage cycle can be 2, 4, 8, or 16, depending on the main-storage capacity.

Central Processing Unit

The central processing unit (CPU) is the controlling center of System/360. It provides facilities for:

Addressing main storage.
Fetching and storing data.
Arithmetic and logical processing of data.
Executing instructions in a desired sequence.
Initiating communication between main storage and input/output (I/O) devices.

The CPU also provides 16 general registers and 4 floating-point registers. These registers are accessible to the programmer and are capable of receiving data, holding it, permitting it to be operated on, and transferring it. The *general registers* are used primarily for fixed-point, logic, and addressing operations. The *floating-point registers* are used only for floating-point arithmetic.

Two major sections of the CPU are the system control section and the arithmetic/logic unit. The system control section directs the sequential accessing of instructions and coordinates both instruction execution and storage fetches. The arithmetic/logic unit, as its name implies, performs the arithmetic and logic operations.

Arithmetic and Logic Operations

The arithmetic and logic operations fall into four classes:

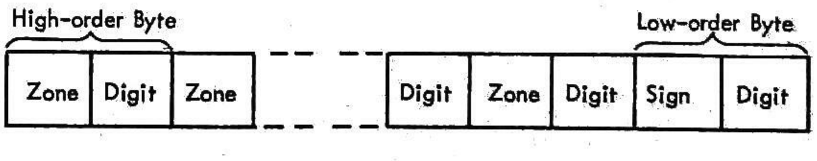
Decimal arithmetic
Fixed-point arithmetic
Floating-point arithmetic
Logic operations

These classes differ in the data formats and field lengths used, the registers involved, and the operations provided.

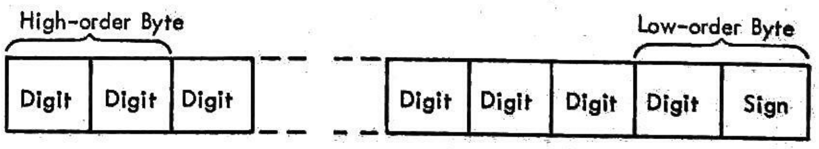
Decimal Arithmetic

Decimal arithmetic, used principally for commercial applications, is performed on signed decimal numbers. Generally, decimal data goes into and out of the system in a *zoned* format (Figure 2-5) and is converted internally to the *packed* format (Figure 2-6) for processing. Packing fits two decimal digits (or one digit and sign) per byte. Because only four binary digits are needed to express one decimal digit, packing permits more efficient handling of decimal data.

Packed data is taken from main storage, processed, and returned to storage without using any general



● Figure 2-5. Zoned Decimal Number Format



● Figure 2-6. Packed Decimal Number Format registers; this is called *storage-to-storage* processing. This form of processing frees decimal data from being restricted to the general registers' four-byte length. The decimal field length, specified by the instruction, can therefore be expanded to as many at 31 digits plus sign, all packed in 16 bytes.

Fixed-Point Arithmetic

Fixed-point arithmetic is used to perform arithmetic operations on both data and storage addresses. This combined use permits the fixed-point instructions (as well as several logic instructions) to be used in address computation, permitting shifting and logical manipulation of address components.

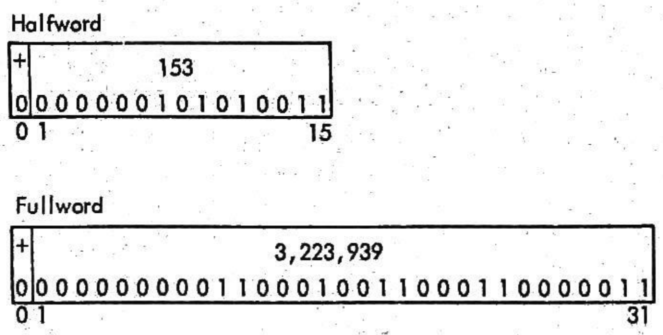
The fixed-point binary word, the basic arithmetic operand in System/360, consists of four bytes of binary data with the binary point to the right of the units position. Halfword operands (Figure 2-7) can be specified in many operations where a fullword is not needed, thus improving both performance and storage use.

The 16 general registers, each four bytes wide, are used for fixed-point operations. General registers can also help keep fixed-point product and dividend precision by allowing adjacent registers to be coupled, effectively doubling the register width.

Floating-Point Arithmetic

Floating-point arithmetic, used primarily in scientific applications, greatly increases the speed, precision, and efficiency of computations. In System/360, this form of numeric representation can express positive or negative decimal values from about 10^{-78} to about 10^{76}.

Floating-point numbers may be short (24-bit fractions, with up to seven decimal-place precision), or long (56-bit fractions, with up to 17 decimal-place precision). Floating-point fractions are made up of hexadecimal (base 16) digits, each consisting of four binary digits and having equivalent decimal (base 10) value of 0-15. The short format usually reduces execution times and increases the number of operands that can be stored, whereas the long format provides greater accuracy. (Higher precision is available for some System/360 models; see "Extended-Precision Floating-Point Arithmetic," discussed in Section 3.)



● Figure 2-7. Fixed-Point Number Formats (with Signed Binary Data)

Four floating-point registers, each eight bytes wide, are provided. The availability of these registers eliminates much fetching and storing of intermediate results. The 16 general registers are also used, primarily for indexing and address arithmetic.

Logic Operations

The logic operations provide System/360 with the ability to logically manipulate data. The manipulations include: comparing, testing, translating (character for character), editing (sign and punctuation control), and relocating logic data. The data may have either a fixed- or variable-length format (Figures 2-8 and 2-9). Fixed-length data, processed through the general registers, may be one, four, or eight bytes long; variable-length data, processed storage-to-storage, can extend to 256 bytes.

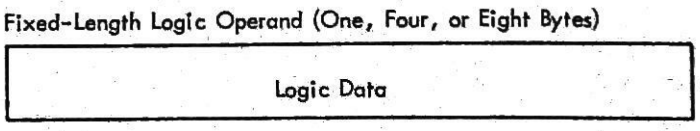
Instruction Formats

Main storage addressing and the execution of processing programs are directed by the CPU. The instructions that make up these programs may be of several different formats, identified by the format codes RR, RX, RS, SI, and SS (Figure 2-10).

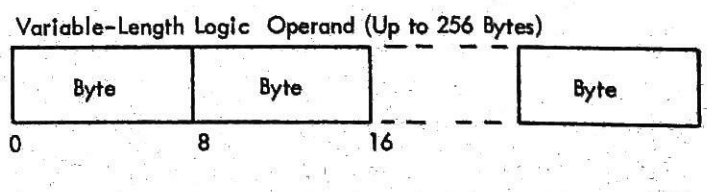
RR denotes a register-to-register operation. The operands are in general registers and the results replace the first operand.

RX denotes a register-and-storage operation. The first operand is in a general register and the second operand is in a main storage location. This format includes a factor for indexing the main storage address; the factor is contained within another general register, which is used as an index register and specified by the instruction. The results of an RX operation may replace the first operand, depending on the instruction.

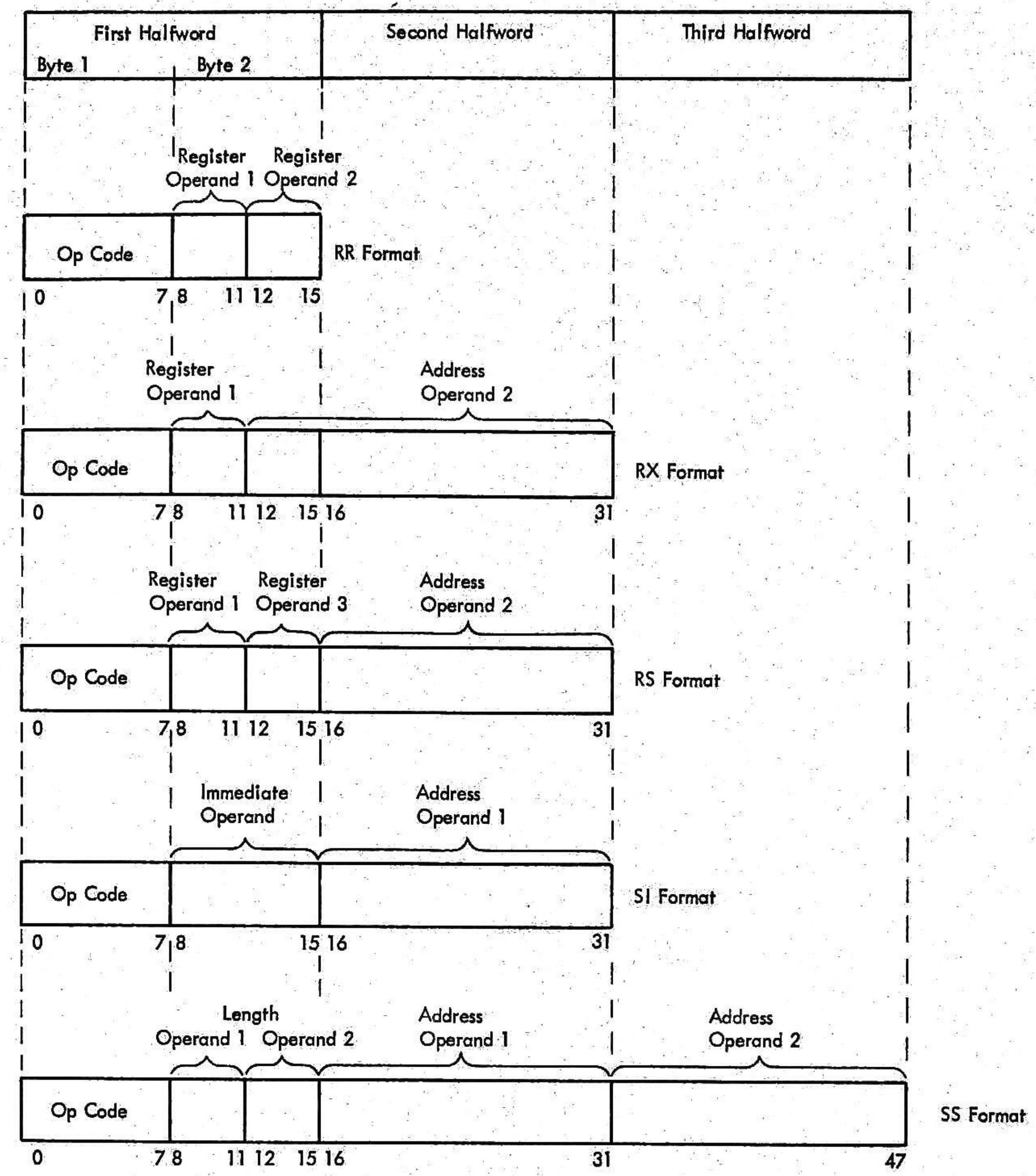
RS denotes a register-and-storage operation. The first operand is in a general register, the second operand is in main storage, and a third may be specified by another general register.



● Figure 2-8. Fixed-Length Logic Format



● Figure 2-9. Variable-Length Logic Format



● Figure 2-10. Basic Instruction Formats

SI denotes an immediate-operand-and-storage operation. The first operand is one byte of data carried in the instruction itself (the immediate operand), and the second operand is in main storage.

SS denotes a storage-to-storage operation. Both operands are in main storage.

The first byte of each of these formats gives the operation code (the "op code"), which identifies the operation to be performed.

System Control Panel

The control panel, usually mounted on the CPU, provides the operator with manual control of the system. It gives the operator the ability to reset a system, to store and display information, and to load initial program information.

The need for operator manipulation of manual controls is minimized by the system design and by the governing control program, reducing the number and seriousness of operator errors.

On the larger System/360 models, the operator controls may also be mounted on a stand-alone console, such as the IBM 2150 Console.

Input/Output

An input/output operation transfers data between main storage and an I/O device. An I/O operation is initiated by a program instruction that generates a command to a *channel.* A *control unit* receives the command via the I/O *interface*, decodes it, and starts the I/O device.

Channels

Channels are the direct controllers of I/O devices and control units. They provide System/360 with the ability to read, write, and compute, all at the same time, by relieving the CPU of the task of communicating directly with the I/O devices.

Channels may be standalone units, complete with the necessary logical and storage capabilities, or they may time-share CPU facilities and be physically integrated with the CPU. The type available to any system model depends on the system model itself. In either case, the channel functions are identical. Channels may be implemented, however, to have different data transfer rates.

Functionally, the channel data path is divided into *subchannels.* To a programmer, each subchannel is treated as a separate channel, and is programmed as such.

Some subchannels can control several I/O devices, whereas others can control only one; these are called *shared* and *nonshared* subchannels, respectively.

System/360 has three major types of channels: byte multiplexer, selector, and block multiplexer.

Byte Multiplexer Channels

Byte multiplexer channels separate the operations of high-speed devices from those of lower-speed devices. Channel operations are in either of two modes: *byte* mode for lower data rates, and *burst* mode for the higher.

In byte mode, the single data path of the channel can be shared by a large number of lower-speed I/O devices (such as card readers, printers, and terminals) operating concurrently; the channel receives and sends data to the I/O devices on demand.

Burst mode is forced by devices such as magnetic tape units, disks, or data cell storage, and is not under the control of the programmer. Such high-speed devices, having established a logical connection with a channel, usually stay connected to it for the duration of data transfer and thereby force the channel into burst-mode state.

The IBM 2870 Multiplexer Channel (Figure 2-11), a standalone unit used with Models 65-195, houses one byte multiplexer channel. Like the in-CPU byte multiplexer channels, the 2870's have *byte multiplexer subchannels;* additionally, 2870's can have *selector subchannels.*

Byte multiplexer subchannels may operate in either byte or burst mode, and may be of either the shared or nonshared type. In byte mode, all subchannels can operate concurrently provided the total load does not exceed channel capacity; each subchannel can operate one low- or medium-speed I/O device. In burst mode, one byte multiplexer subchannel monopolizes the byte multiplexer channel and operates one higher-speed I/O device.

Selector subchannels, which are of the shared type only, operate in burst mode; each can operate one I/O device concurrently with the byte multiplexer subchannels but can control as many as 16 I/O devices.

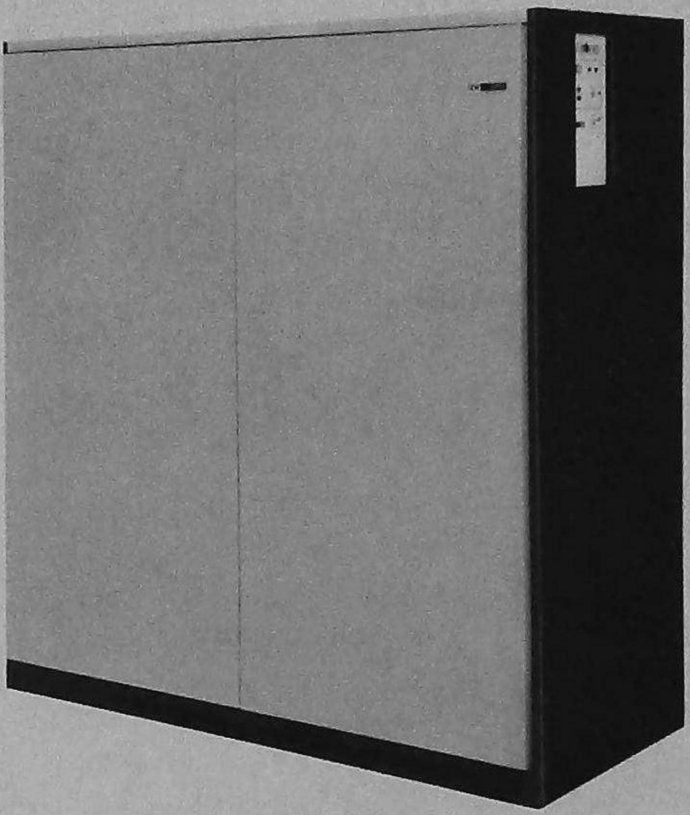


Figure 2-11. IBM 2870 Multiplexer Channel

Selector Channels

Selector channels transmit data to or from a single I/O device at a time. They can handle both high- and lower-speed I/O devices, but their burst-mode operation makes them especially suitable for high-speed devices. Each selector channel attaches up to eight I/O control units and can address as many as 256 I/O devices. One I/O device per selector channel can be transmitting data at any given time; no other I/O device on the channel can transmit data until all data is handled for the selected device.

In general, I/O operations on a selector channel are overlapped with processing, and all channels can operate simultaneously, provided that the processing unit's data rate capabilities are not exceeded. Nominal data rates for the selector channels range from 250 thousand bytes to 1.3 million bytes per second, depending on the system model and the channel options selected.

The IBM 2860 Selector Channel, a standalone unit used with Models 65-195, is similar in appearance to the 2870 Multiplexer Channel, and can house one, two, or three selector channels.

Block Multiplexer Channels

Block multiplexer channels have advantages of both byte multiplexer and selector channels in that they can concurrently operate many high-speed I/O devices on a single data path.

Block multiplexer channels operate in either of two modes: selector or block multiplex. *Selector mode* is functionally equivalent to selector channel operation, permitting attachment of all the I/O devices which can attach to selector channels. In *block multiplex mode*, these channels permit interleaving (multiplexing) of channel programs for high-speed devices in such a way that channel programs can be initiated sooner and channels can be freed earlier than would be possible with selector channels. The byte and block multiplexer channels differ primarily in that the block multiplexer channels can operate with much faster I/O devices, and they transfer larger quantities of data per transmission. These quantities are referred to as *blocks*, and may include a number of records.

Block multiplexer channels provide a number of subchannels of the shared or nonshared type. The maximum data rates for block multiplexer channels vary with the System/360 models and channel options available, and range up to 3.0 million bytes per second.

The IBM 2880 Block Multiplexer Channel, the standalone unit used with the Model 195, is similar in appearance to the 2870, and houses either one or two block multiplexer channels.

I/O Devices

I/O devices fall into a number of categories, some of which overlap. They are used in and for:

Auxiliary storage
Machine and manual (keyed) input, both local and remote
Teleprocessing
Reading (or output) of external documents and displays
Process control
Data acquisition

Many I/O devices function with an external document, such as a punched card or a reel of magnetic tape. Others handle only electrical signals, such as those in process-control and data acquisition systems.

One of the more common I/O devices in System/360 is the IBM 1052 Printer-Keyboard, which permits an operator to communicate directly with the system. Usually, the 1052 is located at the CPU; on larger models, it may also be mounted on a stand-alone console.

Control Units

Control units provide the logic circuitry and the storage areas (buffers) needed to operate the attached I/O devices. Yet, to the user, most control unit functions cannot be distinguished from I/O device functions.

A control unit may be single-path, shared-path, or multipath. A single-path unit, usually integrated with an I/O device, controls only only device. Both shared-path and multipath units can control more than one device and are usually stand-alone units. They differ in that a multipath unit permits several I/O devices to transfer data concurrently, whereas the shared-path unit does not.

I/O Interface

This set of lines provides a uniform method of attaching various I/O devices (through control units) to channels, making System/360 adaptable to a wide range of present and future devices and applications. The information format and the control signal sequences provided by the interface are independent of the type of control unit and channel.

Interruption System

The interruption system permits System/360 to operate nonstop and greatly aids the efficient use of I/O equipment. To make the interruption procedure as short and simple as possible, switching between the interrupted program and the control program (the program that services interruptions) must be efficient. This system operates as follows:

The complete status of System/360 is held in an eight-byte *program status word* (PSW). This status information, which consists of the instruction address, condition code, storage protection key, etc., is saved when an interruption occurs, and is restored when the interruption has been serviced.

As soon as the interruption occurs, all current status information, together with an identification of the cause of the interruption is put into a PSW. This "old" PSW is stored at a fixed location. The system then automatically fetches a "new" PSW from a different fixed location. Each class of interruption uses two fixed locations in main storage: one to receive the old PSW when the interruption occurs, and the other to supply the new PSW that governs the servicing of that class of interruption.

After the interruption has been serviced, a single instruction uses the old PSW to reset the central processing unit to the status it had before the interruption.

Classes of Interruptions

The interruption system separates interruptions into five classes:

Program interruptions are caused by various kinds of programming errors; the exact type of error is identified in the old PSW.

Supervisor Call interruptions are caused when the processing program issues an instruction to pass control to the part of the control program called the *supervisor*, which performs the supervisory functions associated with a task.

External interruptions are caused by an external device that requires attention, by the timer (an internal clocking device) going past zero, or by the operator pressing the interrupt key.

Machine Check interruptions are caused by the machine-checking circuits detecting an error.

I/O interruptions are caused by an I/O unit ending an operation or otherwise needing attention. Identification of the device and channel causing the interruption is stored in the old PSW; in addition, the status of the device and channel is stored in a fixed location.

Disallowing of Interruptions

Most interruptions may be either allowed or temporarily disallowed. When an interruption is disallowed, it is either delayed or does not take place, the outcome depending mainly on the class of interruption. The following can be disallowed:

All I/O interruptions
All external interruptions
Some program interruptions
The machine-check interruption

Specifically, while external and I/O interruptions are disallowed, any external or I/O interruption request is held pending until the interruption is allowed. (An interruption request signal is sometimes called, more briefly, an "interrupt.") While program interruptions are disallowed, the corresponding program interruption request signals are disregarded and do not remain pending. While machine-check interruptions are disallowed, the first machine-check interruption request is held pending until the interruption is allowed, and any machine-check interrupt beyond that first one is disregarded and does not remain pending.

Priority of Interruptions

During the execution of an instruction, several interruptive events may occur simultaneously. When this occurs, the competing interruption requests are serviced in a fixed order of priority:

Machine Check
Program or Supervisor Call
External
Input/Output

The program and supervisor-call interruptions are mutually exclusive and cannot occur at the same time.

When more than one interruption requests service, the action consists of storing the old PSW and fetching the new PSW belonging to the interruption which is taken first. This new PSW subsequently is stored without any instruction execution and the next interruption PSW is fetched. This process continues until no more interruptions are to be serviced. When the last interruption request has been serviced, instruction execution is resumed using the PSW last fetched. The order of execution of the interruption subroutines is, therefore, the reverse of the order in which the PSW's are fetched.

Thus, the most important interruptions — I/O, external, program or supervisor call — are actually serviced first. Machine check, when it occurs, does not allow any other interruptions to be taken.

• Section 3. System/360 Features

This section describes the more prominent standard and optional features of System/360. Each feature is discussed under the heading for the system unit with which it is most easily associated.

Some features are standard for some System/360 models and optional for others; and some features are available to only certain models. (See Section 6 for the features available with any specific model.)

Main Storage Features

Main storage includes all directly-addressable storage; that is, both processor storage (which is part of every System/360) and 2361 Core Storage (large-capacity storage), which is an optional feature for several models.

Processor Storage Capacities

Processor storage capacities offer a wide latitude in choosing the amount of storage required. The capacities vary from 8K (8,192) bytes to 6,144 K (6,291,456) bytes, depending on the system model. Available models have a choice of four to eight storage capacities, with each model's maximum capacity ranging from 3 to 16 times its minimum.

Large-Capacity Storage (LCS), or IBM 2361 Core Storage

The processing power of several larger system models expanded by adding large-capacity storage (Figure 3-1) can be in blocks of either 1,048,576 or 2,097,152 bytes, to a maximum of 8,388,608 bytes. Available capacities are, in round numbers, 1, 2, 4, 6, or 8 million bytes. This storage, located in a separate unit, is addressed contiguously with processor storage. The number of bytes obtained per storage access, the storage protection features, and the other features of LCS (except its 8-microsecond speed) are the same as those of the processor storage of the system to which it is attached.

An advantage of LCS is that it accommodates, in protected storage, large records or vocabularies heretofore located in auxiliary storage media, thereby reducing the number of time-consuming references to I/O devices. Also, LCS can contain large problems, with extensive reference tables, throughout their execution.

If two-way interleaving is specified for LCS, sequential accesses are alternated between two LCS units and partially overlapped, with the effect, on Models 65 and 75, of increasing the maximum sequential access speed from a rate of 1 megabyte per second (8-microsecond speed with eight bytes per access) to 2 megabytes per second (4-microsecond effective rate). In Model 50, only four bytes are fetched per storage access, and interleaving can be specified only where LCS is to be shared with a Model 65 or 75 in a System/360 multisystem. When interleaving is specified, available LCS capacities are, in round numbers, 2, 4, or 8 million bytes.

Shared Main Storage

Central processing units may share either processor storage or large-capacity storage; the two capabilities are separate. The processor storage associated with two or more central processing units may be shared and addressed by each as a single storage unit. LCS may be shared between two or more sytems; the LCS addresses are then an extension of the larger of the two processor storages involved.

Storage Protection

Storage protection, made up of the store and fetch protection features, prevents the unauthorized changing or use of the contents of main storage. *Store protection* prevents the contents of main storage from being altered by storage addressing errors in programs or input from I/O devices. *Fetch protection* prevents the unauthorized fetching of data and instructions from main storage. As many as 15 programs (with associated main storage areas) can be protected at one time.

Protection is achieved by dividing main storage into 2,048-byte blocks and by associating a five-bit *storage key* (Figure 3-2) with each block. Each storage key may be thought of as a lock. Each block of storage, then, has its own "lock." Two instructions are provided for assigning and inspecting the four-bit *code* in a key. The same code may be used by many blocks, using binary codes 0001-1111.

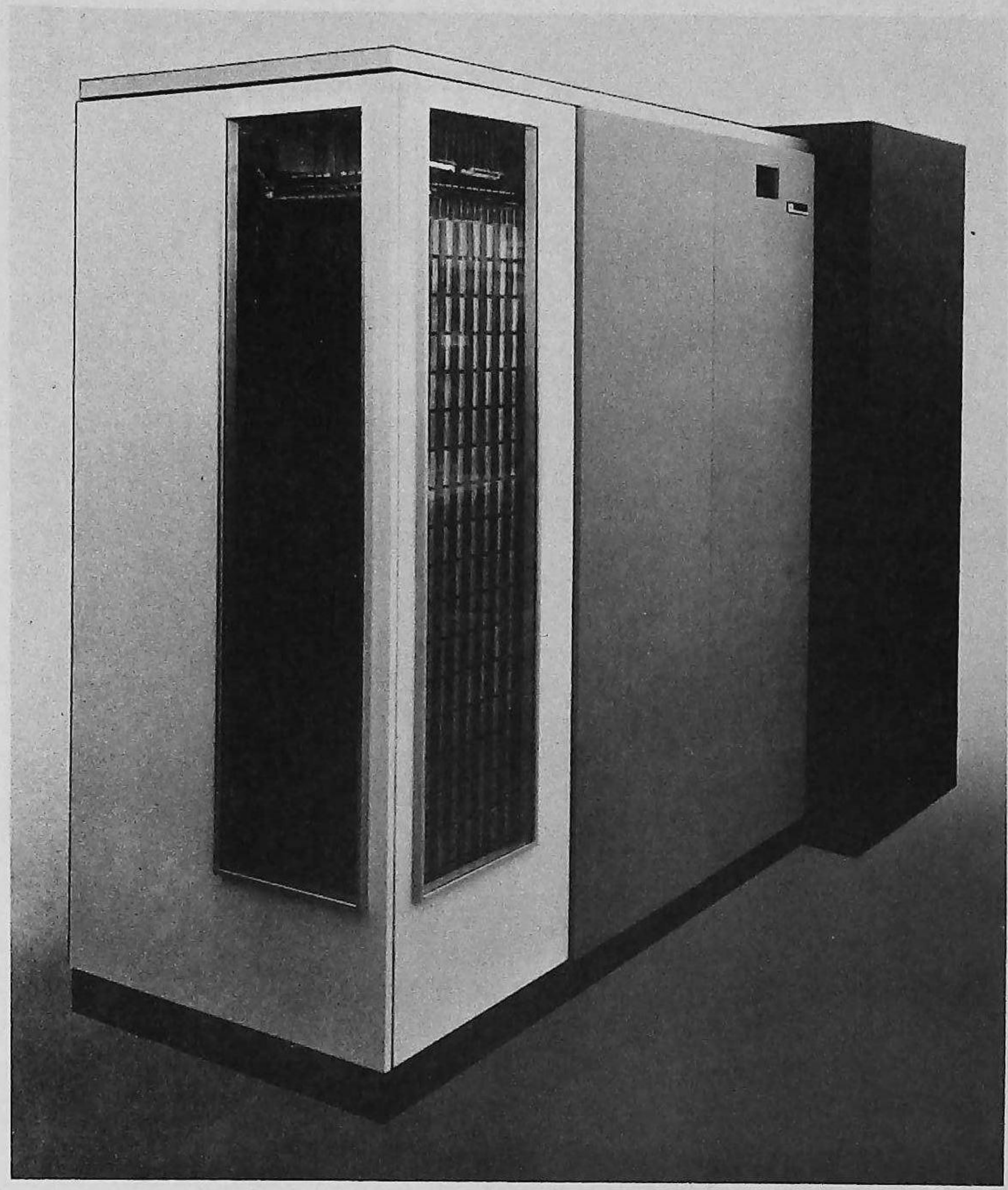


Figure 3-1. IBM 2361 Core Storage (Large-Capacity Storage)

A user's right of access to storage is identified by a four-bit *protection key* (Figure 3-2), located in the program status word (PSW) or in a special word used in channel operations. The protection key may be thought of as the key for the "lock". During a main-storage reference (storing or fetching), the storage key is compared with the protection key associated with the reference. Access to the location is granted only when the four leftmost (high-order) bits of the storage key match the protection key, or when the protection key is zero (0000). When both the store and fetch protection features are installed, the rightmost (low-order) bit of the storage key determines whether fetch protection is operative for the storage block associated with that key. If the bit is 1, fetch protection is operative; if it is 0, it is inoperative.

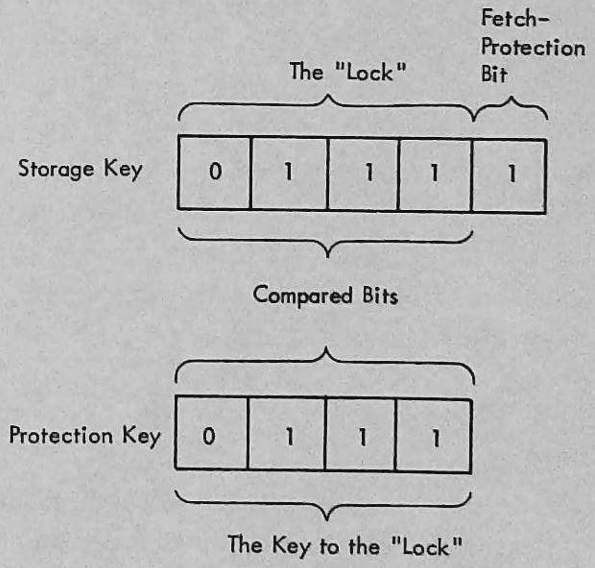


Figure 3-2. Storage and Protection Keys, Showing Matching Keys

Central Processing Unit Features

Instruction Sets

The four major instruction sets available are: *standard, scientific, commercial,* and *universal.* The instructions that make up the standard instruction set provide System/360 with the basic processing instructions and are included with the other sets (Figure 3-3).

Decimal Arithmetic

This feature, especially useful in commercial operations, permits storage-to-storage decimal arithmetic operations and adds two instructions to assist in editing output. The decimal arithmetic instructions, when used with the standard instruction set, make up the commercial instruction set.

Floating-Point Arithmetic

This feature, used primarily in scientific operations, permits calculations on data with a wide range of magnitude. Included with this feature are four 64-bit floating-point registers, which are used to perform these calculations. Operands can be selected for either 24-bit fractions (short precision) or 56-bit fractions (long precision). The floating-point instructions, when combined with the standard instruction set, make up the scientific instruction set.

Extended-Precision Floating-Point Arithmetic

This feature permits floating-point operands to have 112-bit fractions (extended precision) compared to the 56-bit fractions available with long-precision floating-point arithmetic. It also permits results to be rounded from extended to long precision or from long to short precision.

Variable Long-Precision Floating-Point Arithmetic (Model 44)

Controlled by a switch at program execution time, this feature permits a user to adjust for 32, 40, 48, or 56-bit fractions, with a consequent reduction in execution time for the shorter precisions.

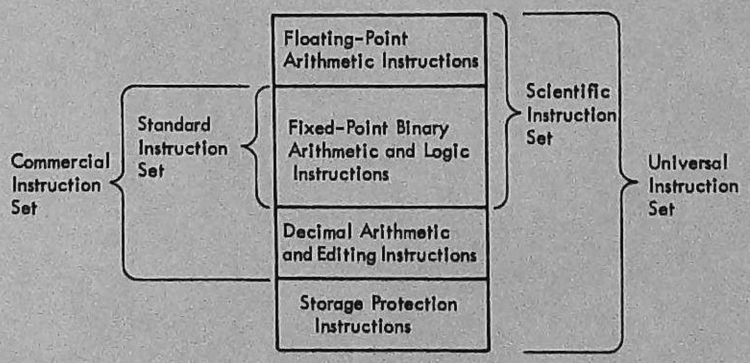

Floating-Point Arithmetic Instructions
Standard Instruction Set
Fixed-Point Binary Arithmetic and Logic Instructions
Scientific Instruction Set
Commercial Instruction Set
Universal Instruction Set
Decimal Arithmetic and Editing Instructions
Storage Protection Instructions

Figure 3-3. System/360 Instruction Sets

Direct Control and External Interrupt

Direct control provides for exchanging control signals between two System/360 central processing units, or between a System/360 and some specialized device, such as an analog-digital converter.

Direct control bypasses the channel by using the direct-control instructions and six external interruption lines, each of which, when pulsed, sets up the conditions for an external interruption. On some models, the external interrupt feature is available (alone) for users who do not require (or have) the direct-control instructions, but who do require very fast program response to interruptions from time-dependent I/O devices such as the IBM 1419 Magnetic Character Reader and the IBM 1428 Alphameric Character Reader.

Direct Word and Priority Interrupt (Model 44)

Direct word is similar to direct control, but it has no interruption lines. It also differs significantly in passing four bytes at a time rather than a single byte.

Direct word is primarily intended for the direct exchange (bypassing the channel) of control signals between the CPU and a variety of non-IBM external devices in the function of data acquisition. It is controlled by two instructions.

Priority interrupt provides even faster response times than external interrupt and can identify as many as 256 external conditions at each of its 32 levels. These functions are independent of those of the single-level, six-line external interrupt feature (which may be installed together with priority interrupt).

Priority interrupt is primarily intended for distinguishing many external situations involving non-IBM equipment; with a minimum of programming, it permits immediate physical branching to an unusually large number (8,192) of response routines. Priority interrupt, like direct word, is controlled by two instructions.

Byte-Oriented Operand

The byte-oriented operand feature allows the user to ignore, in part, the restriction that all operands in main storage must be at addresses that are integral multiples of the operand length. The user that takes advantage of this feature can reference fixed-point, floating-point, and logical operands of most RX- and RS- format instructions on any byte boundary.

The operation performed when the byte-oriented operand feature is used is called *boundary alignment.*

Programming Note: Boundary alignment causes instruction processing to proceed at less than optimal speed. Severe performance degradation may result when boundaries are unaligned.

Dynamic Address Translation

When many users have access to main storage, at any one time, the size of all programs being processed may exceed the capacity of main storage to accommodate them. Dynamic address translation, a combination of advanced programming and circuitry, permits each user to program as though he had sole use of a large, contiguously addressable storage area. On the Model 67, this storage area is about 16 million or 4 billion bytes, depending on whether the standard or the extended dynamic address translation feature is chosen.

Only the active parts of programs reside in main storage; the remaining parts are stored in secondary storage devices. When these parts are called into main storage as needed, they are put in any available location. This procedure is automatic and places no burden on the programmer, who remains unaware that he is not the sole user of the system.

Emergency Power-Off Control

Every System/360 CPU has an emergency power-off switch (on the system control panel), which can remove all electrical potential from all cable-connected units directly controlled by the CPU. Switches for installations with two or more cable-connected CPU's or cable-connected units that can be operated "off-line" (that is, not under direct control of a CPU) are required to be interconnected; this provides, in effect, a single emergency power-off switch. Where units or systems in the same "room" or "area" are not cable-connected, interconnection is strongly recommended.

High-Speed Buffer Storage

This unique feature, integrated with the CPU, can sharply reduce the time required for fetching currently used sections of main storage. On the Model 85, for example, the use of buffer storage can reduce the *effective* storage cycle time to between one-third and one-quarter of the actual storage cycle time.

The buffer, though much smaller in capacity than main storage, is quite efficient; most data fetches are made from the buffer rather than from main storage. The buffer achieves high efficiency by using a method of selecting data (for buffer storage) based on the sequential nature of most programs; that is, a storage fetch from some portion of main storage is likely to be followed by other fetches from subsequent locations in that same portion. In a system having buffer storage, such a portion (called a block) is loaded into the buffer, thereby readying the system for fast access to that block. In this way, the buffer is loaded with data most likely to be needed. When the buffer is filled, a fetch from another portion of main storage causes new data to replace the least active block of data in the buffer.

High-Speed Multiply

The high-speed multiply feature allows both fixed-point and floating-point multiply instructions to be performed faster. The basic CPU of the Model 85, for example, does a floating-point long-precision multiply in about 1,870 nanoseconds and a fixed-point multiply in about 780 nanoseconds; with the high-speed multiply feature installed, the times required for the two operations are 610 and 420 nanoseconds, respectively.

Instruction Retry

The instruction retry feature automatically examines any failing instruction and in most cases reattempts its execution. For most instructions, retry involves restarting the instruction unit at the address of the instruction to be retried, and completely re-executing the instruction.

For SS-format logical instructions, re-execution consists of restarting at the last byte successfully processed rather than re-executing the entire instruction.

Timers

The timer for System/360 is one of two types: a line frequency timer, or a high-resolution timer. Either type can be used as an interval timer to measure elapsed time, or can be programmed to tell the time of day. With an appropriate program, either timer can be used to measure the duration of a job, poll a communication network at regular intervals (such as every minute or every 15 minutes), and record the time of program completions.

The *line-frequency timer* is counted down every 1/50th or 1/60th of a second, depending on the line frequency. The *high-resolution timer,* however, uses an oscillator that counts down at much shorter intervals (for example, every 13 microseconds on the Model 67).

An external interruption occurs automatically when time runs out, unless it is disallowed. The full duration for either timer, from the maximum stored value to the time when the interruption signal is generated, is 15.5 hours.

Time Sharing

Time sharing permits many users at remote terminals to use a system as if each were its only user. The computer may actually be switching among many terminals and processing many programs, giving each terminal a small slice of its available time. Time sharing is especially applicable to scientific and engineering problems, where:

1. The computations are not usually of a repetitive nature.
2. It is advantageous to enter a problem piecemeal into the computer and observe intermediate results before proceeding with the computation.

The Model 67 can provide apparently simultaneous operations to various users at remote terminals. It can operate in this time-sharing mode 24 hours a day and process batch jobs during the time available between calls from remote terminals for computing.

Channel Features

High-Speed Multiplexer Channels (Model 44)

High-speed multiplexer (HSMPX) channels have higher maximum data-transfer rate capabilities than the conventional multiplexer channel or the 2870. As many as two HSMPX channels can be attached, each available with a single subchannel and optionally extendable to two, three, or four subchannels.

Each HSMPX subchannel can maintain one data-transferring operation at a time and can recognize two device addresses. Alternatively, in place of one (or both) of the device addresses, the subchannel can recognize a shared-path control unit with up to 16 device addresses.

No more than two control units may be attached to an HSMPX subchannel. A subchannel that is not shared but which can recognize only two device addresses may be able to support only one single-path control unit if both device addresses are used by that control unit.

Direct Data Channel (Model 44)

The direct data channel provides a very fast but simple data transfer capability for the Model 44. It can attach as many as eight I/O devices and can transfer data, four bytes at a time, at rates as high as four million bytes per second.

A prerequisite for the direct data channel is the first high-speed multiplexer (HSMPX) channel. Installing the direct data channel, however, precludes having a second HSMPX channel.

Channel-to-Channel Adapter

This adapter provides a path for data transfers between two channels and synchronizes such transfers, providing systems with interchannel communication.

The channels may be either within the same system or on separate systems. Within one system, an adapter can permit the moving of blocks of data from one area in main storage to another. Connecting a channel of one system to a channel of another has the effect of interconnecting two CPU's.

The adapter uses one control-unit position on each of the two connected channels, but only one channel need have the adapter.

System Features

Compatibility Features for Other IBM Systems

A number of features are available that permit operation of certain models of System/360 by the use of programs written for other IBM systems. These compatibility features are combinations of circuitry and programming that make the System/360 able to read programs written for the other system and to function like that system. In many cases, the program runs much faster on System/360 than on the system for which it was written.

Compatibility features are also called *emulators*, but not simulators. The latter, although they may perform the same function, do so with programming alone and thus run slower.

A compatibility feature is particularly useful when the user needs time to convert his present programs to System/360 code but, at the same time, wants the advantages offered by System/360. In addition, using such a feature may eliminate the need for converting programs that are seldom used.

Sufficient storage and appropriate or equivalent I/O devices must be available for the use of a compatibility feature. Furthermore, the use of one compatibility feature usually precludes the use of another. Under unusual conditions, a feature may not be able to maintain exact compatibility; for example, programs that are time-dependent may not yield indentical results, and the handling of error conditions may differ.

In Figure 6-9 is a list of the compatibility features presently available and of the models of System/360 in which they may be incorporated if minimum and matching configuration requirements are met.

System Partitioning (Duplex Model 67-2)

A Model 67-2 with two CPU's may be partitioned into two independently operated systems. This can be achieved by programs that refer exclusively to certain components, but it is more desirable to partition components from the rest of the system by means of centrally located controls.

Such means are provided by the IBM 2167 Configuration Unit, a console-like component on which the partitioning switches and indicators are located. Partitioning from the required 2167 provides for operation of two-CPU systems as one multisystem (basic) or as independent systems. If one or more components become inoperative, partitioning permits them to be bypassed for continuing service.

Section 4. System/360 Programming Systems

The System/360 programming support supplied by IBM is aimed at minimizing the time and effort required by the user to produce and process programs. Programming support ranges from relatively simple programs to highly sophisticated operating systems. It falls in three categories:

Basic Programming Support
Special Systems Support
Operating Systems

Basic Programming Support (BPS)

The BPS programs provide support for minimum card and tape configurations. BPS furnishes a large number of independent programs, each performing its specific functions, and provides translators for the following programming languages:

Assembler
Report Program Generator (RPG)
FORTRAN

BPS also includes utility programs (e.g.,write tape to cards, write disk to tape), sort/merge programs, and Autotest (a program testing and modifying facility). Other BPS programs support applications for optical and magnetic character readers.

Most BPS programs require only 8K bytes of main storage (K = 1,024).

Special Systems Support

Model 44, a scientific and engineering system, and Model 67, a time-sharing system, have special programming support consistent with the particular applications of these systems. (Support for these models is discussed briefly in Section 6.)

Operating Systems—General Facts

An operating system is a collection of programs that provides for the preparation and execution of the user's problem programs (jobs). IBM-supplied operating systems are designed to match the needs of the equipment configuration and the customer's job requirements.

All operating systems are either tape-resident or direct-access-resident and consist of two basic parts:

Control program
Processing programs

Control Program

The control program is the framework of an operating system; it has three distinct functions:

Job management
Task management (Supervisor)
Data management

Job Management provides the facilities to read, interpret, initiate, and terminate jobs submitted for processing. It also provides the facilities for the operator to comunicate with the system.

Task Management is the core of an operating system. Because it performs the supervisory functions associated with the execution of a task, it is often called the supervisor. The functions provided generally include interruption handling, resource allocation, fetching of non-resident routines, time supervision, and transient-error recovery.

Data Management provides the functions of record blocking and deblocking, space allocation on direct access devices, processing of labels, and the transfer of data between main storage and external devices, all by means of various *access methods*. These functions allow data sets (sometimes called data files) and their processing the utmost independence from the I/O environment. The access methods used are well-defined and consistent ways of handling data sets according to their basic organization: sequential, indexed sequential, direct, partitioned, etc. Some access methods provide automatic buffering facilities.

Processing Program

A processing program is defined as any program that is not a control program. Processing programs are kept on tape or direct access devices, as collections of data sets known as libraries, and fall in three general categories:

Language Translators for Assembler, FORTRAN, COBOL, PL/I, etc.

Service Programs such as utilities and sort/merge.

User-Written Problem Programs that become part of the operating system library and are retrievable by name alone.

Specific Operating Systems

The operating systems supplied by IBM have been designed in modular fashion so that functions may be incorporated according to the need of the user and the size of his equipment configuration. The operating system is created and integrated with the equipment at the time of installation during an operation called *system generation.*

The four IBM-supplied operating systems for the System/360 are:

System/360 Basic Operating System (BOS)
System/360 Disk Operating System (DOS)
System/360 Tape Operating System (TOS)
System/360 Operating System (OS)

BOS

BOS is resident on IBM 2311 Disk Storage in a System/360 with at least 8K bytes of main storage. In addition to a control program, BOS includes Assembler and RPG language translators, utilities, a disk sort/merge program, and Autotest.

DOS/TOS

DOS/TOS are 2311 or 2314 disk-resident and 2400-series tape-resident, respectively, in a system having at least 16K bytes of main storage; however, to realize the full potential of either DOS or TOS, at least 32K bytes is recommended. These operating systems offer additional functions commensurate with progressively larger systems; they also provide facilities for multiprogramming and (with DOS) teleprocessing. Each provides a control program, five language translators (for Assembler, RPG, FORTRAN, COBOL, and PL/I), utilities, sort/merge programs, Autotest, and special-purpose librarian programs—including those for the maintenance of and printed/punched output from libraries. TOS provides a multiprogramming facility that permits the concurrent execution of two or three programs, DOS also permits multiprogramming, and provides communications functions through Basic Telecommunications Access Method (BTAM).

OS

OS is the most sophisticated and the most powerful of the operating systems. It is designed for use on most System/360 models. It may be used on Model 67, but only when the special time-sharing system for that model is not in use. With the sacrifice of a few functions—perhaps not needed for a particular installation—OS can be integrated in a system having as little as 32K of main storage. To take advantage of most options, however, at least 64K bytes is required; the storage size must be estimated for each system or multisystem according to the OS facilities actually needed. OS is resident on direct access devices having a data rate that the using model of System/360 is capable of accepting. OS offers three control programs:

Primary Control Program (PCP)
Multiprogramming with a Fixed Number of Tasks (MFT)
Multiprogramming with a Variable Number of Tasks (MVT)

PCP is the base on which all control programs are built. It schedules and executes job steps one at a time. When generating a programming system, functional capabilities may be selected in a variety of combinations and added to those included in PCP to produce additional capabilities.

MFT reduces the problem of CPU wait-time by supervising the execution of more than one job at a time. Each job is executed in its own area of main storage. The size of each of these areas, or *partitions*, is established when the system is generated, but may be changed by the operator. MFT is especially useful to users who must process a wide variety of jobs that require a corresponding variety of computing system resources. The system's capability of providing partitions as small as 8K bytes is a distinct advantage to the user with many small jobs.

MVT also supervises execution of more than one job step at a time, but in addition, allocates main storage dynamically to each job. This configuration supports the large job customer and the customer who has many small jobs.

Before MVT can schedule a job, the programmer must request, through a control language, the amount of main storage required and the devices required. Because a single job will probably not require all of main storage nor all devices, the remaining resources can be given to other jobs. The programmer also has some control over the sequence of job scheduling. Instead of scheduling jobs in the order in which they are submitted, MVT schedules jobs according to specified priorities.

When more than one job is being executed at the same time, each job competes for the machine and program resources it needs. The main factor in resolving the competition for machine resources is the scheduling priority of the job. When two jobs are being executed, the job with the higher priority uses the CPU when needed.

MVT extends the idea of priorities beyond between-job competition for resources to competition within jobs; i.e., different priorities can be given to separate tasks of a job step.

The recommended minimum storage capacities are 64K bytes for PCP, 128K bytes for MFT, and 256K bytes for MVT.

The facilities of BOS, DOS, and TOS are depicted in Figure 4-1. A diagram of OS is available on a card in color; see *Operating System/360 Chart*, Form V25-6156.

Programming Systems Glossary

*Assemble***. To prepare a machine language program from a symbolic language program by substituting absolute operation codes for symbolic operation codes and absolute or relocatable addresses for symbolic addresses.

*Assembler***. A program that assembles.

*Compile**. To prepare a machine language program from a computer program written in another programming language by making use of the overall logic structure of the program, or generating more than one machine instruction for each symbolic statement, or both, as well as performing the function of an assembler.

*Compiler***. A program that compiles.

*Initial Program Loader (IPL)**. The procedure that causes the initial part of an operating system or other program to be loaded such that the program can then proceed under its own control.

IOCS. Input/Output Control System.

*Linkage***. In programming, coding that connects two separately coded routines.

Linkage Editor. A program that produces a load module by transforming object modules into a format that is acceptable for execution, combining separately produced object modules and previously processed load modules into a single load module, resolving symbolic cross references among them, replacing, deleting, and adding control sections automatically on request, and providing overlay facilities for modules requesting them.

Load Module. (1) The output of the linkage editor. (2) A program in a format suitable for loading into main storage for execution.

*Macro Instruction***. An instruction in a source language that is equivalent to a specified sequence of machine instructions.

*Module**. A program unit that is discrete and identifiable with respect to compiling, combining with other units, and loading; for example, the input to, or output from, an assembler, compiler, or linkage editor.

*Object Module**. A module that is the output of an assembler or compiler and is input to a linkage editor.

*Program Library***. A collection of available computer programs and routines.

*USASI proposed definition
**U.S. Standard definition

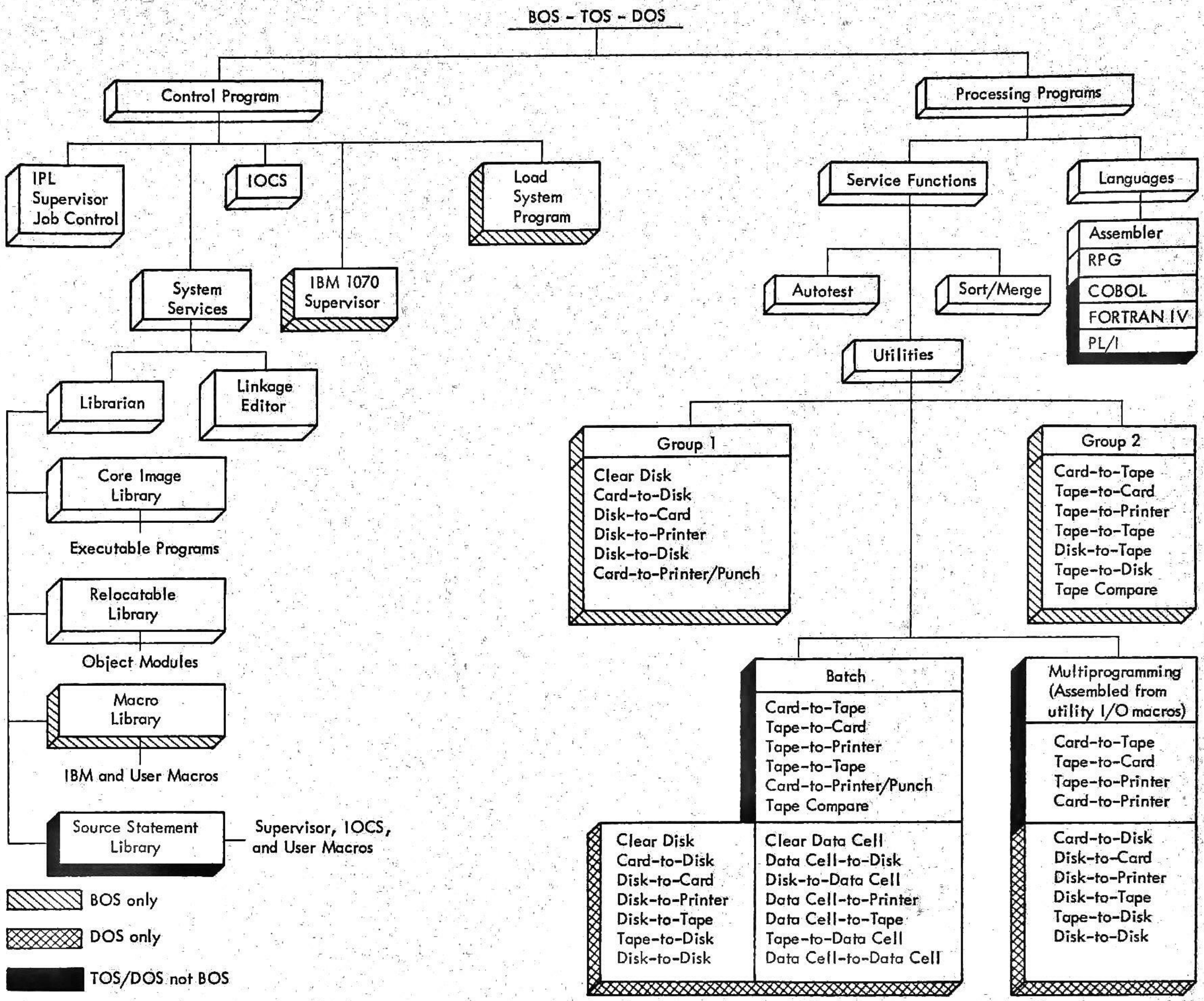


Figure 4-1. Facilities of BOS, TOS, and DOS

Section 5. Teleprocessing, Data Acquisition, and Process Control

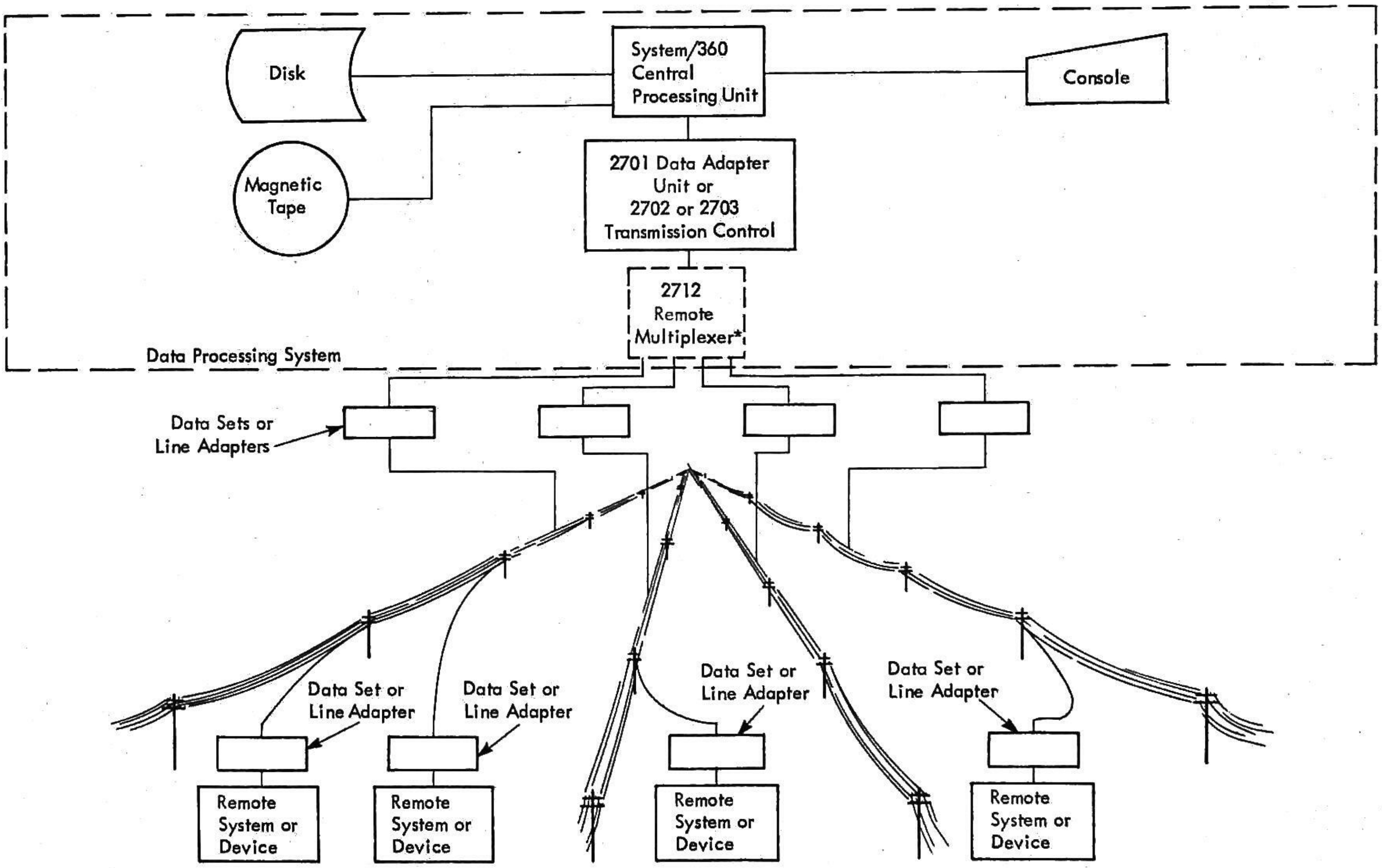
Teleprocessing

One of the major considerations in designing System/360 was that the system would have to serve as the data processing complex within a larger teleprocessing system. (Figure 5-1)

IBM's past experience with real-time and teleprocessing systems indicated that there are two major differences between teleprocessing systems and the more familiar batch processing systems: batch processing input is scheduled, whereas teleprocessing input is unscheduled; batch processing is usually serial, whereas teleprocessing is random. To incorporate the ability to service these two teleprocessing characteristics into a system that would probably be used mostly for batch processing, the System/360 designers had to create new equipment and new programming conventions.

As an example of how a teleprocessing system functions, suppose that a clerk in an insurance company's branch office receives a telephone call asking for information about an insured's account. Asking the caller to hold the line, the clerk enters the information request into a terminal, and the request is sent over a communications line to the System/360 at the insurance company's main office. When the request reaches the computer, several things happen. The computer interrupts processing whatever job it is working on (perhaps the payroll is being run) and saves all necessary data and instructions so that it can resume processing at exactly the point in the program it had reached before it was interrupted. As the information is received over the communications lines, the communications module in the control program converts the data into machine language, stores it in a buffer area, and checks to see that it was transmitted correctly.

The nature of the request may dictate that a number of different operations must be performed. To process the request, the teleprocessing program directs the System/360 to run through the appropriate policy file



* Optional Device. Attachable to 2702 or 2703.

Figure 5-1. System/360 as a Teleprocessing System

and bring the insured's record from storage. The program then searches the record for the information requested and sends it out over the communications lines to the clerk who originated the request. The clerk reads the information as it is typed out at his terminal and relays the information to the policyholder or adjuster waiting on the telephone. Back at the main office, the control program has returned the System/360 to its status prior to the interruption by the inquiry, and the computer has resumed processing the payroll program.

Requirements of a Teleprocessing System

A careful examination of the preceding example reveals that any teleprocessing system must meet certain requirements. System/360 was designed to respond to all of these requirements without sacrificing its efficient performance of the ordinary batch data processing needs of science and industry.

Transmission Control Capability

The system may be servicing many locations, some on common communications lines and some on separate lines. Equipment and programming are therefore required to handle the multiple inputs arriving in unscheduled fashion into the System/360.

Program Switching

On a single transaction, the control program initiates several switches among the various programs; therefore, the processing unit must be designed to accomplish very rapid program switching.

Program Relocation

The processing unit must also have the ability to dynamically relocate programs in storage during normal processing, because many different types of transactions may necessitate bringing a program from peripheral storage into a location in main storage for which the program was not originally assembled.

Storage Protection

With multiple programs residing in the system at one time and with constant program switching and relocation taking place, it is imperative that there be a facility available that can prevent one program from changing another program's instructions and data.

Transmission—Directions, Grades, and Modes

A circuit, channel, or line is a path for electrical transmission between two or more terminals. Basically, IBM equipment can operate over three types of circuits: simplex, half-duplex, and duplex (also called full duplex). These circuit names describe only directional capability.

Simplex Circuits can carry data in only one direction.

Half-Duplex Circuits can carry data in two directions but in only one direction at a time.

Duplex Circuits can carry data in two directions at the same time.

A network can consist of any combination of these circuits according to application requirements.

Grades

The three types of circuits are each graded on their transmission rates in terms of characters per second, bits per second, or words per minute. There are four circuit grades: broad band, voice grade, subvoice grade, and telegraph. However, there are no rigid limitations separating one grade from another.

Broad Band Circuits transmit data at a rate that is limited only by the band width available: microwave, radio signals, or coaxial cables are often used to carry data rapidly from point to point.

Voice Grade Circuits can handle about 2,400 bits per second. A voice grade circuit can be divided into several smaller circuits, each suitable for subvoice or telegraph communications.

Subvoice Grade Circuits are usually considered to be those operating at a transmission rate less than 600 bits per second.

Telegraph Circuits operate at speeds ranging from approximately 45 to 75 bits per second.

Modes

Information can be transmitted over the various types and grades of circuits by three different modes of transmission:

1. *Asychronous Transmission* (also called serial start/stop) requires the use of start and stop bits to designate the beginning and ending of characters.
2. *Synchronous Transmission* eliminates the need for start and stop bits; a special pattern of bits is sent periodically to keep the transmitter and receiver operating in unison. The bit pattern is generated automatically and sent as required by the system.
3. *Parallel Transmission* allows all bits of a character to be transmitted simultaneously by providing one circuit for each bit in the code structure.

Most often a user obtains his communications lines from a communications common carrier. The common carrier leases him a private channel (line) for his exclusive use or connects him with the telephone network available to the public. A user can also purchase and maintain his own communications facilities, but these must be purchased from suppliers other than common carriers. There are numerous government regulations concerning the connection of privately owned communications facilities to those owned and maintained by common carriers.

Terminal Connections to Communications Lines

In this System Summary the word "terminal" refers to a machine or group of machines capable of generating and/or receiving signals transmitted over a communications line. Within this definition a terminal may range from a data processing system, such as System/360, to a single device, such as an IBM 2740 Communication Terminal. A terminal may be connected to another terminal by a point-to-point line or by a multipoint line. A *point-to-point* (common carrier leased or private) line connects a single terminal to another single terminal, whereas a *multipoint* line connects more than two terminals. On circuits with little traffic, its use often results in a cost saving. Terminals sharing the same line may or may not have the ability to communicate with each other.

Data Sets

A data set is a modulation-demodulation device (*modem*) used to connect business machines to communications lines. *Modulation* is the conversion of digital signals from the business machine to audio frequency signals for transmission over communications lines. *Demodulation* reconverts the information for machine use. One data set is required at each interface between the communications facilities and the data processing equipment. The data set may be supplied by a communications common carrier or, under certain circumstances, by IBM. An IBM-supplied data set is called a *line adapter*. Because of legal restrictions, IBM line adapters can only be used on customer owned transmission lines or on lines leased from common carriers. Line adapters and common-carrier data sets cannot be mixed within the same network.

Data Acquisition and Process Control

A high-speed data acquisition system is designed to maintain constant communication with a process for such purposes as:

1. Determining whether the process is operating within acceptable limits.
2. Providing records for accounting or management decisions.
3. Providing a record of data obtained during a research experiment.

A process control system usually incorporates data acquisition facilities and has the additional capability of using the acquired data as a basis for supervising and controlling the process.

Section 6. System/360 Models

The various models and input/output configurations within the System/360 cover a wide range of commercial and scientific data-handling requirements. Presently, ten models of the System/360 are covered in the System Summary: Models 22, 25, 30, 40, 44, 50, 65, 67, 75, and 195. In this section, the more prominent features and characteristics of each model are brought together to describe each model individually. Figure 6-9, which compares each model's prominent features and characteristics with those of the other models, appears at the end of this section. The devices that can attach to the individual System/360 models are described in the next two sections and are listed in Figures 7-1 and 8-1.

System/360 Model 22

The System/360 Model 22 (Figure 6-1) has the power and capabilities to meet a wide variety of scientific and commercial needs at a relatively low cost. Provided either 24K (24,576) bytes or 32K (32,768) bytes of main storage, this model has a selector channel and byte multiplexer channel that allow the attachment of a wide variety of I/O devices. Other features, both standard and optional, further enhance the capabilities of the Model 22.

Standard Features

Standard or commercial instruction set
Byte multiplexer channel
Selector channel

Optional Features

Scientific or universal instruction set
External interrupt
Interval timer
Storage protection
Integrated 1052 attachment

System Components

Central Processing Unit: IBM 2022 Processing Unit

Basic Machine Cycle Time: 0.75 microsecond (750 nanoseconds).

Instruction Sets: Either the standard or commercial instruction set is provided with the Model 22. Either set can be replaced by the scientific or universal set.

External Interruption: The external interrupt feature provides six external interruption lines for requesting a response from the Model 22 and for identifying the request.

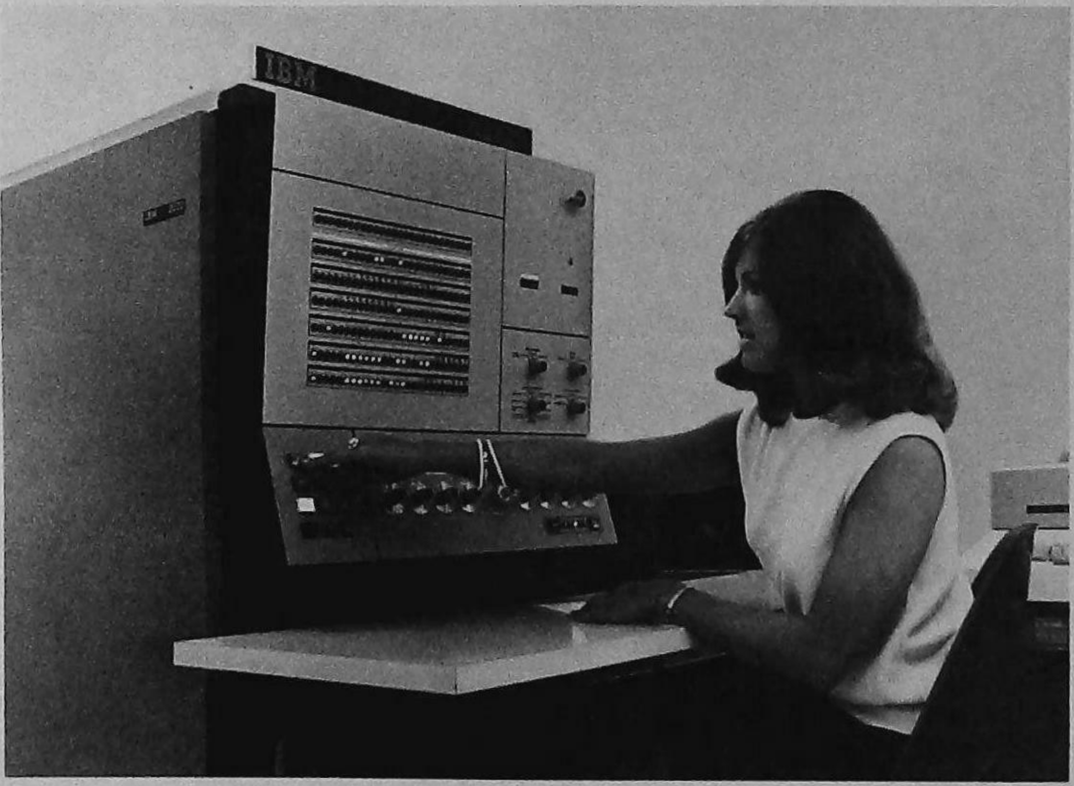


Figure 6-1. IBM System/360 Model 22

Main Storage: Part of 2022 Processing Unit

Storage Sizes:

CAPACITY (BYTES)	MODEL
24,576	DC
32,768	E

Storage Cycle Time: 1.5 microseconds.

Storage Access Width: One byte.

Channels: Part of 2022 Processing Unit

Byte Multiplexer Channel: The byte multiplexer channel provides 96 subchannels and eight control-unit positions.

Selector Channel: The selector channel, which has a data rate of 170,000 bytes per second, uses a microprogram interruption to control data transfers.

Interchannel Connection: The Model 22 can communicate with other models of System/360 by the direct connection of channels, but only if the other model has a channel-to-channel adapter. The adapter requires the use of one control-unit position on each of the two channels.

Programming Support

DOS is the primary programming support for the Model 22. Other existing System/360 applications and programming systems support can be used by the Model 22 within the limitations of storage capacity, channel capability, and CPU features.

System/360 Model 25

Delivering System/360 performance at relatively low cost, the System/360 Model 25 (Figure 6-1.1) offers features such as main storage capacities of up to 49,152 bytes, channel capabilities, decimal and floating-point arithmetic, and compatibility with the System/360 Model 20 and the IBM 1401, 1440, and 1460 Data Processing Systems.

High performance at minimal cost has been achieved in several ways: by the inclusion of high-speed circuitry for main storage, by the use of microprogramming for emulator and control routines, and by the integrated attachment of the most commonly used I/O devices, in which the normally separate control units are incorporated in the CPU.

Standard Features

Commercial instruction set
Attachment for 1052 Printer-Keyboard Model 7

Optional Features

Scientific or universal instruction set
Byte multiplexer channel or selector channel (one of either)
Store protection
Direct control (with external interrupt) or external interrupt (alone)
Timer (line-frequency type)
1401/1460 compatibility
1401/1440/1460 DOS compatibility
1440 compatibility
System/360 Model 20 mode
CPU-integrated attachments for:
- One 1403 Printer Model 2, 7, or N1 (with multiple character set adapter)
- As many as four 2311 Disk Storage Drives Model 1 (with file scan feature)
- One 2540 Card Read Punch Model 1 (with column binary feature and punch feed read control)
- One 2560 Multi-function Card Machine Model A1 (for Model 20 mode; also for System/360 mode [read/punch only] if the 2540 emulation feature is added)

CPU-integrated communications attachment

System Components

Central Processing Unit: IBM 2025 Processing Unit

Basic Machine Cycle Time: 0.90 microsecond (900 nanoseconds).

Instruction Set: The commercial instruction set is provided with the Model 25. This set can be replaced by the optional scientific or universal instruction set.

Control Signal Exchange and External Interruption: The direct control feature is optional; it includes the external interrupt feature.

CPU-Integrated I/O Attachment: The CPU provides for the integrated attachment of a 1052 Printer-Keyboard Model 7 and the following I/O devices: one 1403 Printer Model 2, 7, or N1, as many as four of the 2311 Disk Storage Drive Model 1, one 2540 Card Read Punch Model 1, and one 2560 Multi-function Card Machine Model A1. Each of these devices can connect

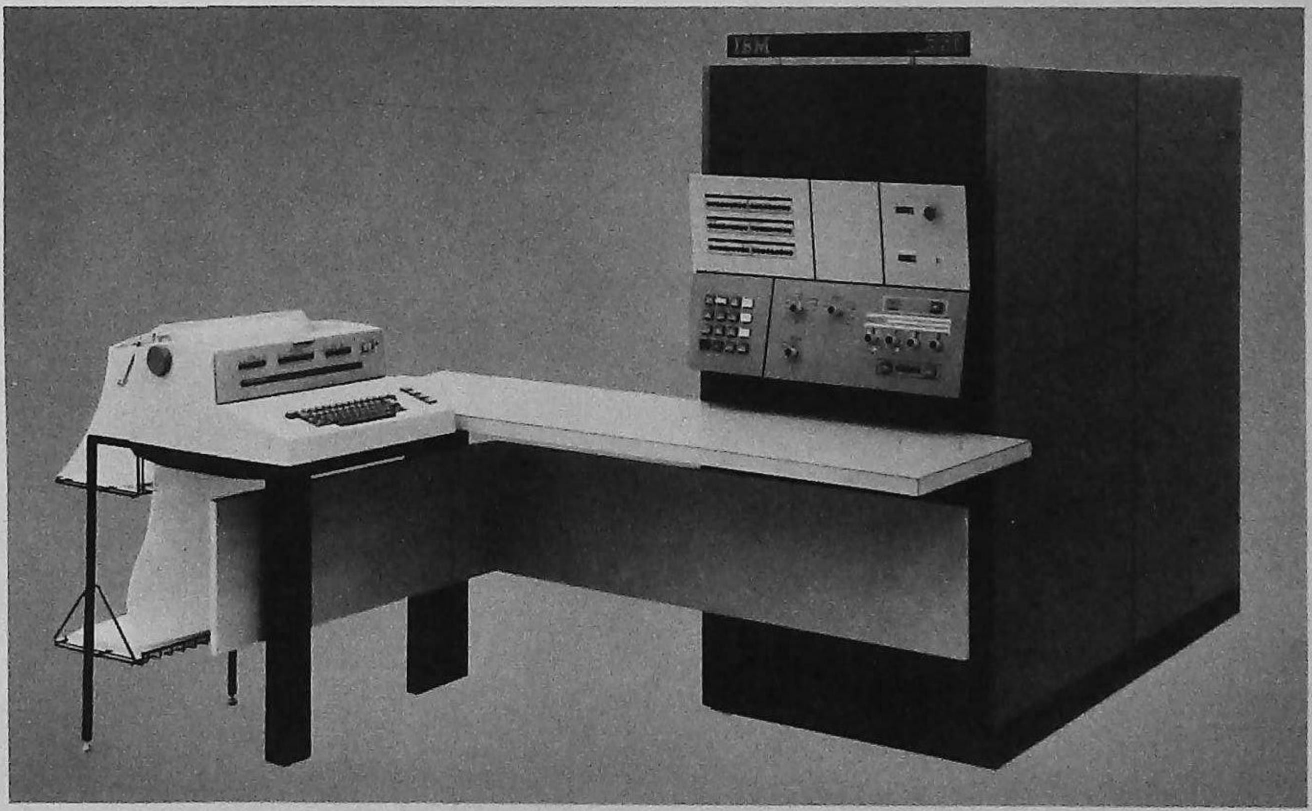


Figure 6-1.1 IBM System/360 Model 25 with 1052 Printer-Keyboard

to the CPU by means of an appropriate attachment feature and does not require a control unit (2821 or 2841) physically attached to an I/O channel, although to the program the device appears to be on a channel and is addressed accordingly.

In addition to the integrated units, a wide range of other I/O devices is available for attachment to the Model 25 through the use of either a byte multiplexer or selector channel (both optional). For further details, see Figure 7-1.

CPU-Integrated Communications Attachment: This feature provides teleprocessing entry for Model 25 users through direct attachment of communications lines to a Model 25 rather than through a 2701 Data Adapter Unit or 2702 Transmission Control on a byte multiplexer channel. (See Figure 8-1.)

Main Storage: Part of 2025 Processing Unit

Storage Sizes: The Model 25 has four possible storage sizes:

CAPACITY (BYTES)	MODEL
16,384	D
24,576	DC
32,768	E
49,152	ED

Storage Cycle Time: 1.8 microseconds (1,800 nanoseconds). Storage cycle time is the length of time that storage is busy when a reference is made to it.

Storage Access Width: Two bytes (one halfword).

Protection Features: Store protection is optional.

Channels: Part of 2025 Processing Unit

Byte Multiplexer Channel: When the byte multiplexer channel is operated in byte mode, the I/O devices can operate concurrently with each other, with the integrated devices, and with CPU operations. In burst mode, I/O devices can overlap their operations with those of integrated devices but not with CPU operations. With the Model 25, magnetic tape units cannot be used on the byte multiplexer channel.

Selector Channel: This channel can overlap integrated-device and CPU operations and has a maximum data transfer rate of 60,000 bytes per second. The selector channels of Model 25's built prior to February, 1969 have a maximum data rate of 30,000 bytes per second, but will be modified to have the higher data rate.

Interchannel Connection: The Model 25 can communicate with other System/360 models by the direct connection of channels, but only if the other model has a channel-to-channel adapter. The adapter requires the use of one control-unit position on each of the two channels.

System

Compatibility Features: The features that can be installed on the Model 25 are: 1401/1460 compatibility, 1440 compatibility, 1401/1440/1460 DOS compatibility, disk storage operations (for processing 1311 disk information), and System/360 Model 20 mode. The 1401/1440/1460 DOS compatibility feature cannot be installed if the Model 25 has either the scientific instruction set or the integrated communications attachment.

System Control: The Model 25 is operated, monitored, and controlled via the system control panel on the 2025 Processing Unit.

Programming Support

The Model 25 can use System/360 application and programming systems support. Existing BPS, BOS, TOS, and DOS programs apply to the Model 25, within the limitations of the storage capacity and channel capabilities.

System/360 Model 30

The System/360 Model 30 (Figure 6-2) offers versatility with economy for both scientific and commercial applications. On this model, a wide choice of storage capacities (exceeding those of the Model 25), interchannel connection, 1400-series and 1620 compatibility features, and channel attachments for a large number and variety of I/O devices are available.

The storage capacities of the Model 30 range from 16,384 to 65,536 bytes, offering users the opportunity to closely match storage to their needs. The byte multiplexer channel, a standard feature, provides as many as 224 subchannels and permits the attachment of as many I/O devices.

The versatility of the Model 30 can be increased by adding a channel-to-channel adapter, which permits this model to operate as either a peripheral system or an independent one. As a peripheral system, it can handle functions for a larger System/360 model, freeing it for other tasks; these functions include the smoothing of peak-load scheduling, the handling of system overflow, and system backup.

Also on the Model 30, users of the IBM 1401, 1440, 1460, and 1620 Data Processing Systems can run unconverted programs; under most circumstances, these programs can be run both faster and more economically.

Standard Features

Standard instruction set
Byte multiplexer channel

Optional Features

Commercial, scientific, or universal instruction set
Timer (line-frequency type)
Store protection
Selector channels (as many as two)
Additional byte multiplexer subchannels (total of 224)
Direct control (with external interrupt) or external interrupt (alone)
1401/1440/1460 compatibility or 1620 compatibility
Channel-to-channel adapter
Attachment for 1052 Control Unit

System Components

Central Processing Unit: IBM 2030 Processing Unit

Basic Machine Cycle Time: 0.75 microsecond (750 nanoseconds).

Instruction Set: The standard instruction set is provided with the Model 30. This set can be replaced by the optional commercial, scientific, or universal instruction set.

Control Signal Exchange and External Interruption: The direct control feature is optional; it includes the external interrupt feature. The external interrupt feature (available separately) provides six distinct external interrupt lines for requesting a response from the Model 30 and for identifying the request.

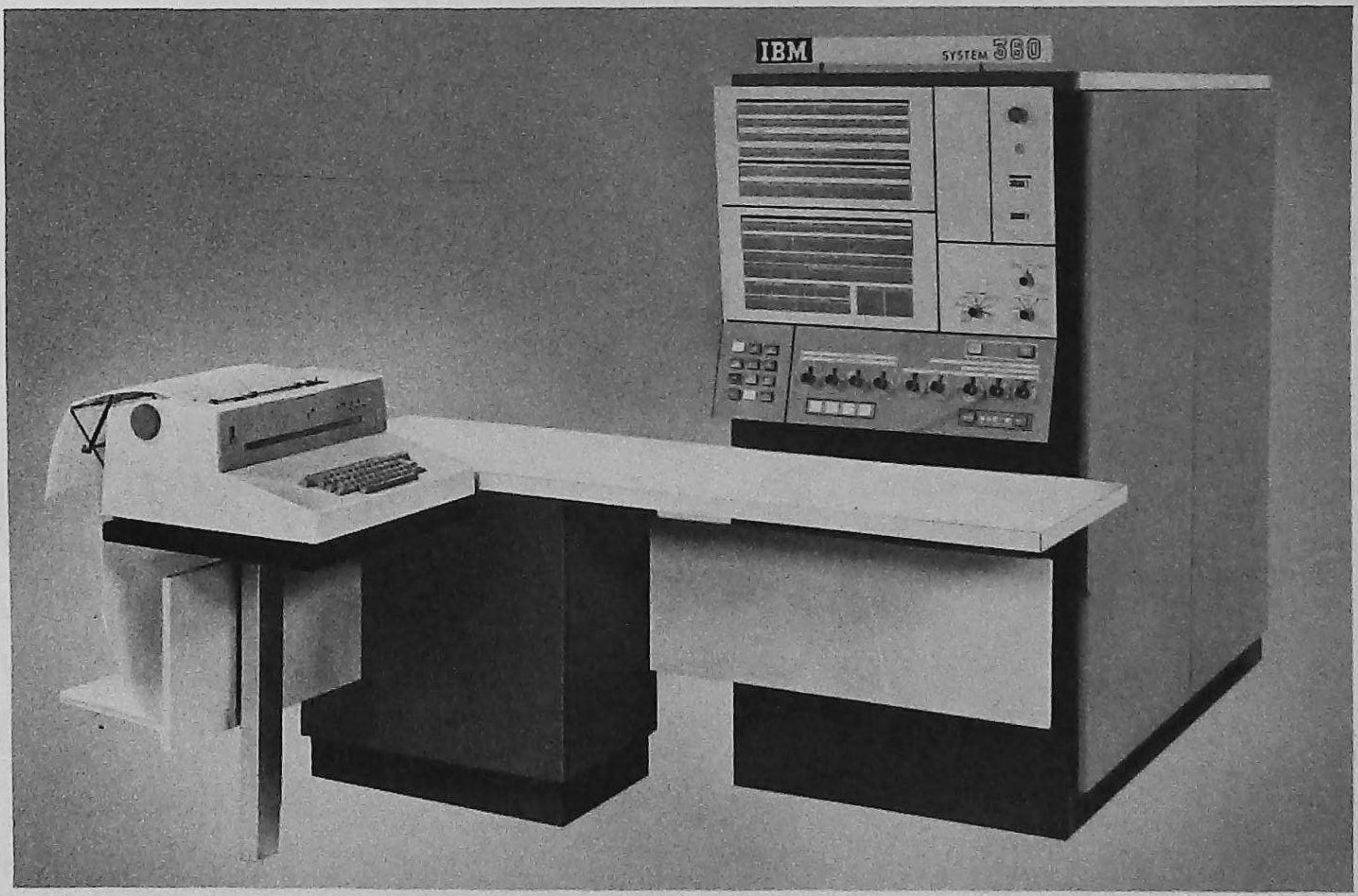


Figure 6-2. IBM System/360 Model 30 with 1052 Printer-Keyboard

Main Storage: Part of 2030 Processing Unit

Storage Sizes:

CAPACITY (BYTES)	MODEL
16,384	D
24,576	DC
32,768	E
65,536	F

Storage Cycle Time: 1.5 microseconds (2.0 on earlier models).

Storage Access Width: One byte.

Protection Features: Store protection is optional; fetch protection is not a feature for the Model 30.

Channels: Part of 2030 Processing Unit

One byte multiplexer channel is standard on the Model 30, and one to two selector channels are optional. The number of byte multiplexer subchannels varies from 96 to as many as 224 (with the additional byte multiplexer subchannels feature).

BYTE MULTIPLEXER SUBCHANNELS	MODELS
96	All
224 (optional)	E, F

Interchannel Connection: One channel-to-channel adapter may be installed on either a byte multiplexer or a selector channel, permitting communication between two channels (on the same system or on different systems). One control-unit position is required on each of the connected channels. A second channel connection can be made with another system if an adapter is installed on the other system.

System

Compatibility Features:

COMPATIBILITY FEATURE	APPLICABLE MODELS
1401/1440/1460 DOS	All but D
1401/1460	All
1440	All
1620	All

Installation of one compatibility feature precludes installation of another.

System Control: The Model 30 is operated, monitored, and controlled via the system control panel on the 2030 Processing Unit.

Programming Support

The Model 30 is supported by BPS, BOS, DOS, TOS, and by OS with PCP.

System/360 Model 40

The System/360 Model 40 (Figure 6-3) has the power and capabilities to meet a wide variety of scientific and commercial needs. Its main storage capacity (from 32,768 to 262,144 bytes) is, at its maximum, four times larger than the main storage capacity of the Model 30. Its attachable I/O devices include the 2303 Drum Storage, providing nearly four million bytes of direct-access storage with a maximum data transfer rate of 303,800 bytes per second. The Model 40 also offers compatibility features to users of the IBM 1401, 1410, 1440, 1460, and 7010 Data Processing Systems that permit them to run unconverted programs on the Model 40 with generally increased speed and efficiency.

Standard Features

Standard instruction set
Byte multiplexer channel
Timer (line-frequency type)

Optional Features

Commercial, scientific, or universal instruction set
Store protection
Selector channels (as many as two)
Channel-to-channel adapter
Direct control (includes external interrupt)
1401/1460 compatibility
1401/1440/1460 DOS compatibility
1410/7010 compatibility
Adapter for 1052 Printer-Keyboard Model 7

System Components

Central Processing Unit: IBM 2040 Processing Unit

Basic Machine Cycle Time: 0.625 microsecond (625 nanoseconds).

Instruction Set: The standard instruction set is provided with the Model 40. This set can be replaced by the optional commercial, scientific, or universal instruction set.

Control Signal Exchange and External Interruption: The direct control feature is optional; it includes the external interrupt feature.

Main Storage: Part of 2040 Processing Unit

Storage Sizes:

CAPACITY (BYTES)	MODEL
32,768	E
64,536	F
131,072	G
196,608	GF
262,144	H

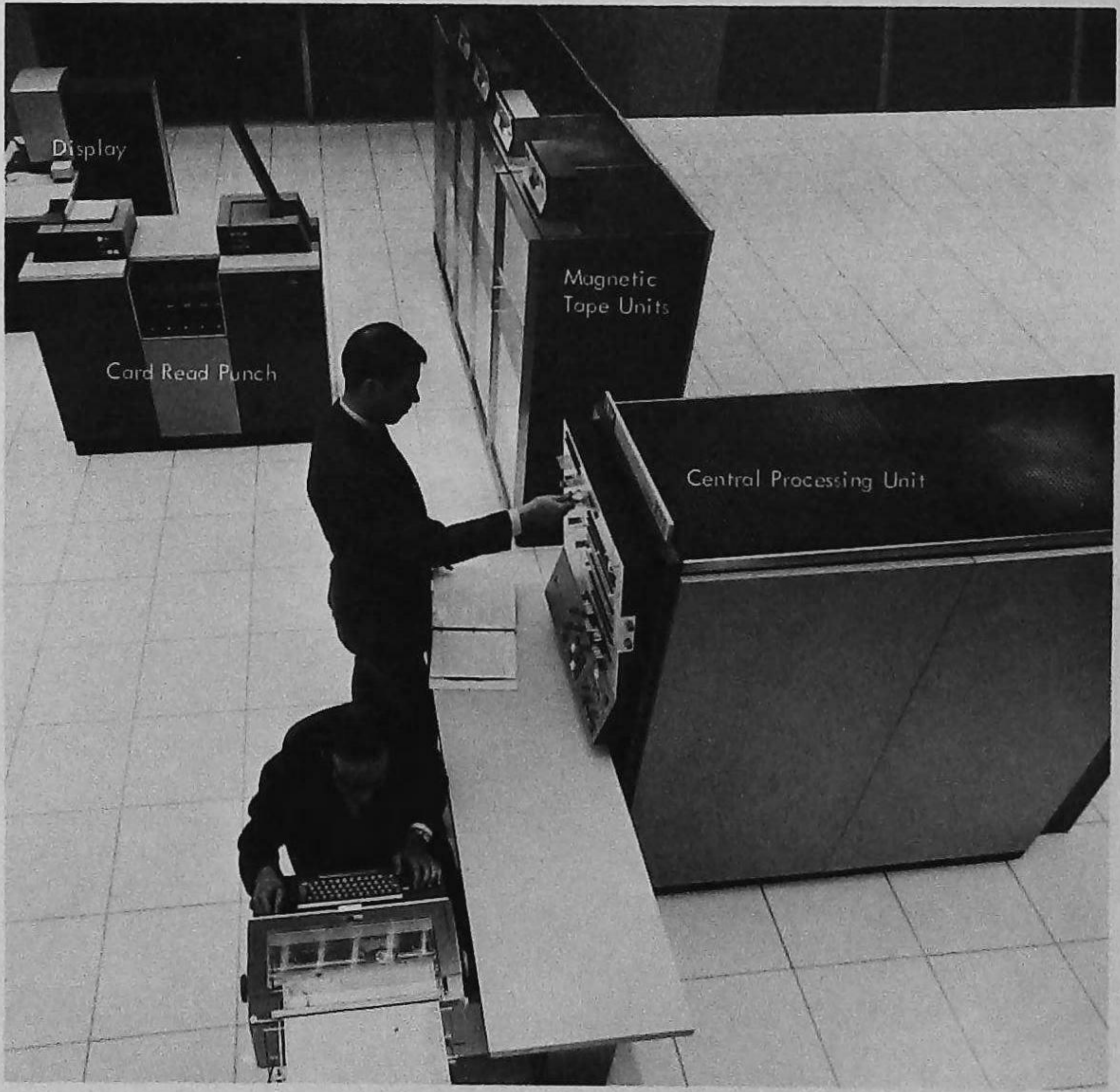


Figure 6-3. IBM System/360 Model 40

Storage Cycle Time: 2.5 microseconds.

Storage Access Width: Two bytes (one halfword).

Protection Features: Store protection is optional; fetch protection is not a feature for the Model 40.

Channels: Part of 2040 Processing Unit

One byte multiplexer channel is standard on the Model 40, and one to two selector channels are optional. Between 32 and 128 byte mutliplexer subchannels are available, depending on which model is used.

BYTE MULTIPLEXER SUBCHANNELS	MODELS
32	E
64	F
128	G,GF,H

Interchannel Connection: One channel-to-channel adapter may be installed on a selector channel and attached to either a byte multiplexer or selector channel. It permits communication between channels (on the same system or on different systems). The adapter requires one control-unit position on each of the connected channels. A second channel connection can be made with another system if an adapter is installed on the other system.

System

Compatibility Features:

COMPATIBILITY FEATURE	APPLICABLE MODELS
1401/1460	All
1401/1440/1460 DOS	All
1401/1440/1460 Relocatable DOS	All but E
1410/7010	All but E

System Control: The Model 40 is operated, monitored, and controlled via the system control panel on the 2040 Processing Unit.

Programming Support

The Model 40 is supported by BPS, BOS, DOS, TOS, and OS.

System/360 Model 44

The System/360 Model 44 (Figure 6-4) is optimized toward scientific applications and has a main storage capacity of up to 262,144 bytes. Features are available that make the Model 44 particularly well-suited for high-speed data and control applications: the direct word feature, the priority interrupt feature, and the direct data channel.

The performance of the Model 44 is enhanced by a 1-microsecond storage cycle time, a four-byte storage-access width, high-speed general registers, and as many as two CPU-integrated single-disk storage devices, each having a storage capacity exceeding one million bytes.

Standard Features

Model 44 instruction set
Timer (line-frequency type)
Single-disk storage drive
Console printer-keyboard

Optional Features

Commercial feature
Floating-point arithmetic (with variable-length precision)
High-speed general registers
Storage protection (both store and fetch protection)
Byte multiplexer channel
High-speed multiplexer (HSMPX) channel (as many as two)
HSMPX subchannels (as many as four per HSMPX channel)
Direct data channel
Direct word
External interrupt
Priority interrupt
Timer (high-resolution type, in place of the line-frequency type)
Single-disk storage drive (a second one)

System Components

Central Processing Unit: IBM 2044 Processing Unit

Basic Machine Cycle Time: 0.250 microsecond (250 nanoseconds).

Instruction Sets: The Model 44 instruction set includes those instructions from the System/360 standard instruction set that are desirable for scientific and engineering applications. Adding the commercial feature provides the Model 44 with the ability to execute all the instructions available in the standard and commercial instruction sets. Adding the floating-point feature (with its long and short precision) to the Model 44 instruction set provides this model with its scientific instruction set.

Control Signal Exchange and External Interruption: The direct word, external interrupt, and priority interrupt features are optional on the Model 44.

The direct word feature provides for the direct transfer (channel bypass) of data between main storage and an external device. Unlike the direct control

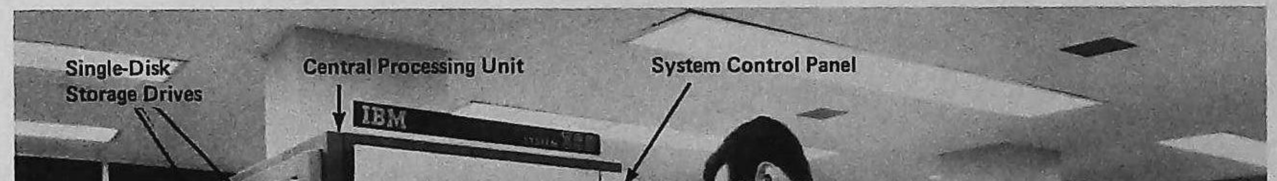


Figure 6-4. IBM System/360 Model 44

feature, it has no interrupt lines, and it transfers four bytes of data at a time rather than one.

The priority interrupt feature, in addition to interrupting the activity of the CPU, provides for quickly distinguishing among many various events and for initiating appropriate responses. As many as 256 possible external conditions can be identified at each of the 32 levels of this feature. With a minimum of programming, priority interrupt permits immediate physical branching to over 8,000 response routines. The functions of the priority interrupt feature are independent of those of the single-level, six-line external interrupt feature, which may be installed along with the priority interrupt feature.

Compatibility with Other System/360 Models: Any program written for the basic Model 44 can be executed on any of the other models if the compatibility constraints of the System/360 are observed. However, programs that depend on certain features available only on the Model 44 cannot be run on any other System/360 model. These features are: the selection of fewer than eight bytes for long-precision arithmetic, the direct word feature, the priority interrupt feature, and the direct data channel.

Commercial Feature: On Models F, G, and H, compatibility can be further increased with the commercial feature, which provides the Model 44 with the ability to execute (primarily by emulation) all the variable-field-length instructions (including decimal arithmetic) available in the standard and commercial instruction sets.

High-Speed General Registers: When the general registers are implemented in high-speed circuitry, the general-register access time is reduced from 1 microsecond to 0.25 microsecond. This reduction of the access time substantially decreases address generation time as well as the basic execution time of all fixed-point instructions.

Variable Long-Precision Floating-Point Arithmetic: With this feature, a user can adjust long-precision instructions (at program execution time) for execution with 4, 5, 6, or the full 7 bytes of precision.

High-Resolution Timer: This optional timer serves the same functions as the line-frequency timer, but its resolution of 13 microseconds is about 8,000 times greater.

Main Storage: Part of 2044 Processing Unit

Storage Sizes:

CAPACITY (BYTES)	MODEL
32,768	E
65,536	F
131,072	G
262,144	H

Storage Cycle Time: 1.0 microsecond.

Storage Access Width: Four bytes (one word).

Protection Features: Store and fetch protection are available as a combined feature; neither is available separately.

Auxiliary Storage

Single-Disk Storage Drives (One Standard and One Optional): Each of these CPU-integrated units provides direct-access auxiliary storage for over one million bytes of storage, with a 70-millisecond average access time and a data rate of 90,000 bytes per second. (These units are further described in Section 7.)

Channels: Part of 2044 Processing Unit

The Model 44 may have one byte multiplexer channel and one or two high-speed multiplexer (HSMPX) channels. A direct data channel may be used in place of a second HSMPX channel. At least one channel is required.

Byte Multiplexer Channel: This channel may have as many as 64 subchannels:

BYTE MULTIPLEXER SUBCHANNELS	MODEL
32	E
64	F,G,H

HSMPX Channel: This channel provides the Model 44 with data transfer rates higher than those of a byte multiplexer channel. Each HSMPX channel may have one to four subchannels, and each of these subchannels permits the attachment of two control units.

Direct Data Channel: This special channel permits the attachment of as many as eight external devices (including non-IBM devices) to the CPU, with aggregate data rates up to four million bytes per second.

Interchannel Connection: The Model 44 can communicate with other System/360 models by the direct connection of channels, but only if the other model has a channel-to-channel adapter. The adapter requires the use of one control-unit position on the Model 44.

System

System Control: The Model 44 is operated, monitored, and controlled via the system control panel on the 2044 Processing Unit.

Console Printer-Keyboard: The console printer-keyboard, a standard feature, permits communication between the operator and the system. Equivalent to a 1052-7, it attaches to one of the system channels by an adapter in the CPU. This feature requires one control-unit position and either one byte multiplexer subchannel or half of one HSMPX subchannel.

Programming Support

The Model 44 Programming System provides comprehensive programming support for this System/360 model. The addition of the commercial feature permits the Model 44 to be supported also by BPS, BOS, DOS, TOS, and OS.

System/360 Model 50

The System/360 Model 50 (Figure 6-5) offers a performance significantly greater than that offered by the Model 22, 25, 30, or 40. Its advantages include: increased storage speed and access width, the overlapping of channel and CPU activities, added channel options, more main storage, and the use of an optional 2361 Core Storage (referred to as Large-Capacity Storage or LCS).

Storage: The maximum storage capacity of the Model 50 is 524,288 bytes. This storage can be expanded with LCS by 1, 2, 4, 6, or 8 million bytes (in rounded figures).

Speed: The Model 50's four-byte storage access width and 2.0-microsecond storage cycle time make this model much faster in its internal processing speed than either the Model 30 or 40. Also, the overlapping of byte multiplexer channel and CPU operations further increases the speed of system operations.

The channel options permit increased speed and versatility in I/O operations. The use of one to three selector channels permits the operation of an equal number of high-speed I/O devices, and the number of subchannels of the byte multiplexer channel can be increased to operate as many as 256 lower-speed devices.

Compatibility: Compatibility features on the Model 50 allow users of the IBM 1410, 7010, 7070, and 7074 Data Processing Systems to run current jobs directly on the Model 50 without reprogramming, often with increased speed.

Standard Features

Universal instruction set
Store protection
Byte multiplexer channel
Timer (line-frequency type)

Optional Features

2361 Core Storage (LCS) with attachment
Shared LCS
Selector channels (as many as three)
Additional byte multiplexer subchannels (total of 256)
Channel-to-channel adapter
Direct control (includes external interrupt)
1410/7010 or 7070/7074 compatibility
Adapter for 1052 Printer-Keyboard Model 7

System Components

Central Processing Unit: IBM 2050 Processing Unit

Basic Machine Cycle Time: 0.5 microsecond (500 nanoseconds).

Instruction Set: The universal instruction set is a standard feature of the Model 50.

Control Signal Interchange and External Interruption: The direct control feature (with the external interrupt feature included) is optional.

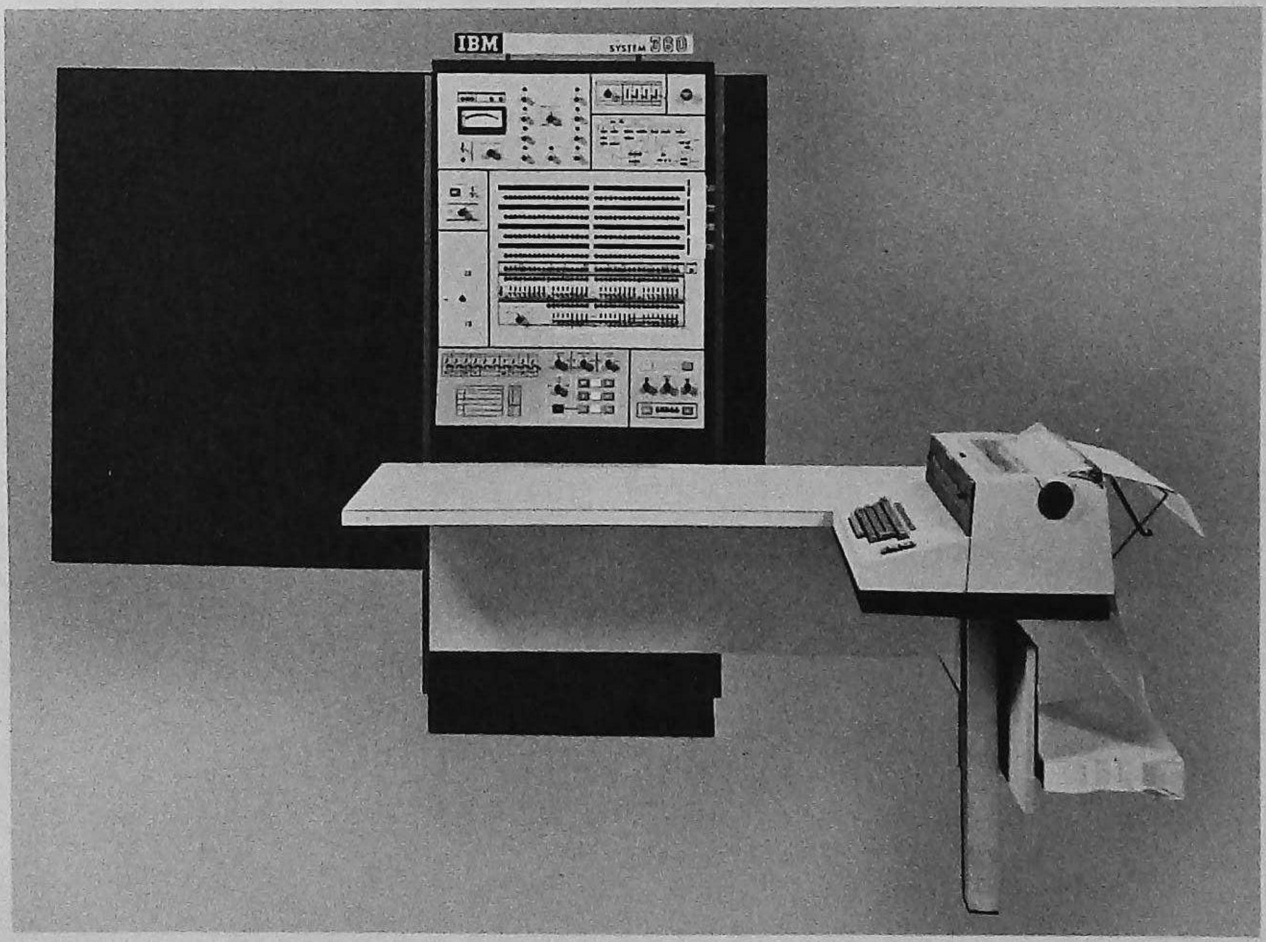


Figure 6-5. IBM System/360 Model 50 with 1052 Printer-Keyboard

Main Storage: Part of 2050 Processing Unit; IBM 2361 Core Storage Models 1 and 2 (Optional)

Storage Sizes:

CAPACITY (BYTES)	MODEL
131,072	G
262,144	H
393,216	HG
524,288	I

Storage Cycle Time: 2.0 microseconds.

Storage Access Width: Four bytes (one word).

Protection Features: Store protection is standard; fetch protection is not a feature for the Model 50.

Large-Capacity Storage: The following units of 2361 Core Storage may be used: one 2361-1 without interleaving but two with it; one to four 2361-2's without interleaving but two or four with it.

Channels: Part of 2050 Processing Unit

One byte multiplexer channel is standard, and one to three selector channels are optional. The byte multiplexer channel has 128 or 256 subchannels (with the additional byte multiplexer subchannels feature).

BYTE MULTIPLEXER SUBCHANNELS	MODELS
128	All
256 (optional)	All but G

Interchannel Connection: One channel-to-channel adapter may be installed on either a byte multiplexer or selector channel, permitting communication between channels (on the same system or on different systems). The adapter requires one control-unit position on each of the connected channels. A second channel connection can be made with another system if an adapter is installed on the other system.

System

Compatibility Features:

COMPATIBILITY FEATURE	APPLICABLE MODELS
1410/7010	All
7070/7074	All but G

Installation of one feature precludes installation of the other.

System Control: The Model 50 is operated, monitored, and controlled via the system control panel on the 2050 Processing Unit. The operator control section of this panel may be duplicated to provide a remote operator control panel and can be mounted on a 2150 Console or a 2250 Display Unit Model 1.

Programming Support

The Model 50 is supported by BPS, BOS, DOS, TOS, and OS.

System/360 Model 65

The System/360 Model 65 (Figure 6-6) offers powerful performance with exceptional versatility in large-system applications. This is achieved primarily with large storage capacity, high speed, compatibility with a large number of systems, and multiprocessing system capabilities.

The Model 65 has a maximum main storage capacity of 1,024K (1,048,576) bytes in a single-CPU Model 65, and with additional features, 2,048K (2,097,152) bytes in the two-CPU Model 65 Multiprocessing System. The storage of a single-CPU system can be supplemented by 1,024K to 8,192K (8,388,608) bytes with 2361 Core Storage (LCS). LCS permits access to large blocks of data without the need for time-consuming references to I/O devices, resulting in both increased capacity and speed.

The Model 65's storage accessing, significantly larger and faster than the Model 50's, also increases the speed of operations. Two-way interleaving further increases the speed of operations by substantially reducing the effective access time.

With the configuration-control panel feature, the multiprocessing (Model 65 MP) system can be formed from two Model 65's operating as a single large-scale system under one control program. The CPU's of each Model 65 are interconnected, and both main storage and the I/O devices are shared. Such a system offers several advantages:

1. It balances the workload among the CPU's, main storage units, and the I/O devices to provide more efficient use of these units. Thus the combined system can operate at close to its top theoretical efficiency, adjusting its full resources at any time to match the workload of each CPU.
2. It increases critical system availability, especially desirable in real-time applications. By the use of the configuration control panel, units can be removed from operation and the system reconfigured without them. Also, programs are available that provide error correction capabilities, further increasing system availability.
3. It provides exceptional flexibility. The system can allow each of the two Model 65's to operate as an independent subsystem, each with its own control program and its assigned main storage and I/O devices.

Standard Features

Universal instruction set
Storage protection (both store and fetch protection)
Attachment for 2870 Multiplexer Channel
Attachment for 2860 Selector Channel
Timer (line-frequency type)

Optional Features

2361 Core Storage (LCS) with attachment (not available for Model 65 Multiprocessing System)
Shared LCS (not available for Model 65 Multiprocessing System)
2860 Selector Channel (providing as many as six selector channels per CPU)
2870 Multiplexer Channel (as many as two per CPU)
Selector subchannels (as many as four on the first 2870, as many as two on a second one)
Channel-to-channel adapter
Direct control (includes external interrupt)
7070/7074, 7080, or 709/7040/7044/7090/7094/7094 II compatibility
Adapter for 1052 Printer-Keyboard Model 7 (as many as two)
Configuration control panel

System Components

Central Processing Unit: IBM 2065 Processing Unit

Basic Machine Cycle Time: 0.2 microsecond (200 nanoseconds).

Instruction Set: The universal instruction set is standard with the Model 65.

Control Signal Exchange and External Interruption: The direct control feature is available as an option and includes the external interrupt feature.

Main Storage: IBM 2365 Processor Storage Models 2 and 13; IBM 2361 Core Storage Models 1 and 2 (Optional)

Storage Sizes:

CAPACITY (BYTES)	MODEL	STORAGE UNITS
262,144	H	One 2365-2
524,288	I, MP	Two 2365-2's or -13's
786,432	IH, MP	Three 2365-2's or -13's
1,048,576	J, MP	Four 2365-2's or -13's
1,310,720	MP	Five 2365-13's
1,572,864	MP	Six 2365-13's
1,835,008	MP	Seven 2365-13's
2,097,152	MP	Eight 2365-13's

The Model 65 MP uses 2365-13's, whereas the single-CPU Model 65 uses 2365-2's. The 2365-2's can be field-converted to 2365-13's.

Storage Cycle Time: 0.75 microsecond.
Storage Access Width: Eight bytes (one dblwd).
Storage Interleaving: Two-way.

Protection Features: Both store and fetch protection are standard features.

Large-Capacity Storage (2361 Core Storage):

	NUMBER OF 2361-1's	NUMBER OF 2361-2's
Without interleaving	1	1 to 4*
With interleaving	2	2 to 4*

*If the system has two 2860's and two 2870's, then the maximum number of 2361's permitted is three rather than four.

Channels: IBM 2860 Selector Channel Models 1-3 and 2870 Multiplexer Channel

The Model 65 can have as many as seven channels per CPU (one byte multiplexer and six selector or two byte multiplexer and five selector) but requires at least one.

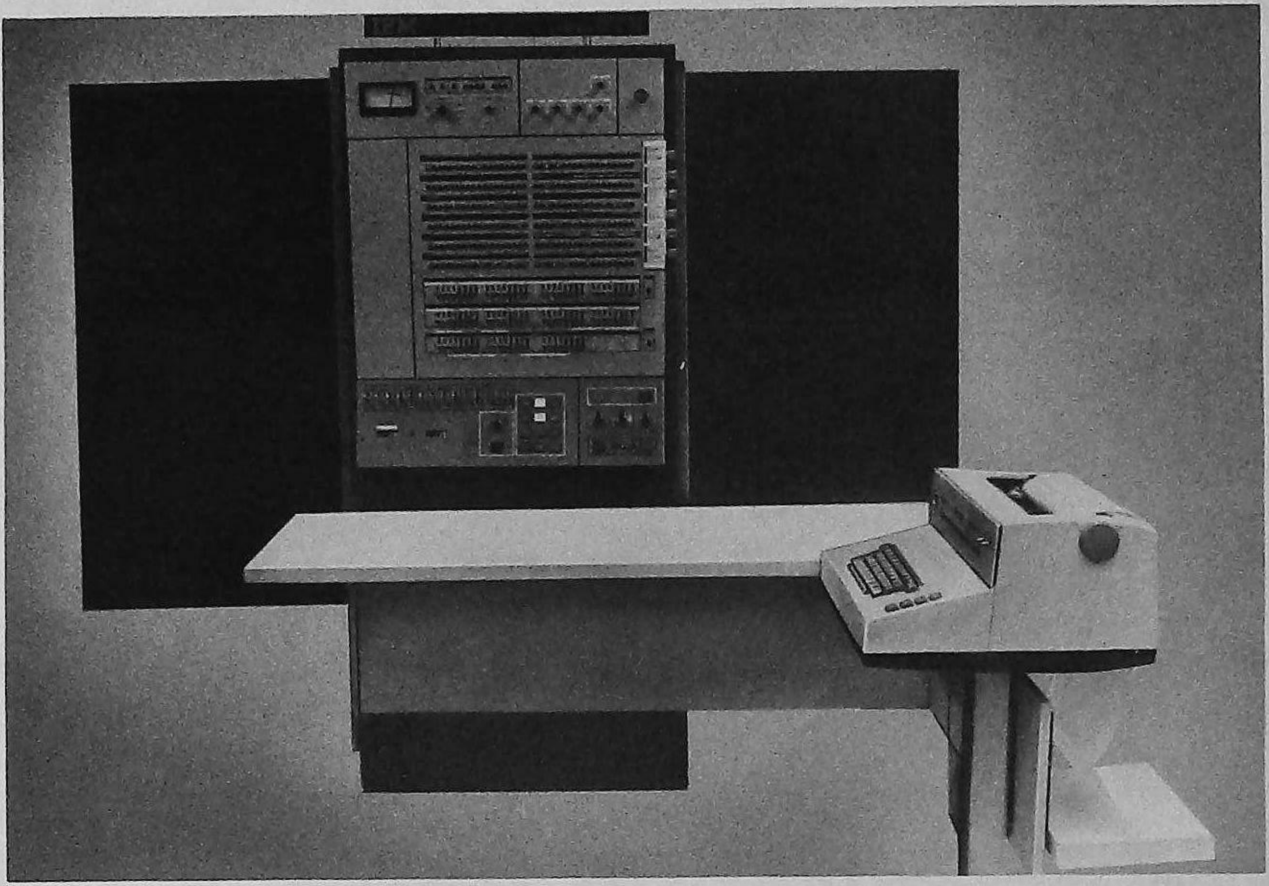


Figure 6-6. IBM System/360 Model 65 with 1052 Printer-Keyboard

The 2870 Multiplexer Channel provides the Model 65 with subchannels:

	BYTE MULTIPLEXER SUBCHANNELS	SELECTOR SUBCHANNELS (OPTIONAL)
First 2870	192	up to 4
Second 2870	192	up to 2*

*None on any second 2870 of a Model 65 MP.

Interchannel Connection: The channel-to-channel adapter is used to interconnect two System/360 channels. On the Model 65, an adapter can be attached for each of the selector channels, permitting each of them to communicate with either a byte multiplexer channel or with another selector channel. The use of an adapter requires one control-unit position on each of the connected channels.

System

Multiprocessing System: The two CPU's of the Model 65 Multiprocessing System share the 2365-13 storage units. Prerequisites of this system are emergency power-off control (on one CPU), the direct control feature, and the configuration control panel.

Compatibility Features:

COMPATIBILITY FEATURE	APPLICABLE MODELS
7070/7074	All
7080	All
709/7040/7044/7094/7094 II	All but H

Only one of these compatibility features (emulators) can be installed on any Model 65 system. For emulation on a Model 65 MP, the required portions of the system must be partitioned out of the system environment; that is, the CPU with the compatibility feature, the appropriate amount of storage, and the required I/O units must be partitioned as a separate system.

System Control: The Model 65 is operated, monitored, and controlled via the system control panel on the 2065 Processing Unit. A remote operator control panel is also available, which can duplicate the operator control section of the system control panel and may be mounted on a 2150 Console or a 2250 Display Unit Model 1. The Model 65 MP has, in addition, a configurator control panel which is shared by the two CPU's and which provides for switching among three modes (multisystem, partitioned, and Model 65), manually assigning storage addresses, and switching I/O interfaces on- or off-line.

Programming Support

The Model 65 is supported by BPS, BOS, DOS, TOS, and OS.

For the control program of OS, the Model 65 uses the Primary Control Program (PCP), Multiprogramming with a Fixed Number of Tasks (MFT), or Multiprogramming with a Variable Number of Tasks (MVT). These are discussed in Section 4. With MVT or MFT, the Model 65 has Recovery Management Support (RMS) programs; they provide the Model 65 with error-correction capabilities, and thereby minimize the impact of machine malfunctions.

The Model 65 Multiprocessing System is an integral part of OS with MVT. Any job that operates with MVT can be processed in the multiprocessing system without changing code, job control language, or data.

System/360 Model 67

Designed primarily for time-sharing applications, the System/360 Model 67 is a unique combination of equipment and advanced programming which provides fast access to this high-performance system from remote terminals.

This model has two basic configurations: the Model 67-1 and the Model 67-2 (Figure 6-7). The Model 67-1 is a one-CPU system with a 2067 Processing Unit Model 1; the Model 67-2 may be a one-CPU (half-duplex) or a two-CPU (duplex) system with one or two 2067-2's, a 2167 Configuration Unit, and a 2846 Channel Controller.

In addition to its time-sharing capability, the Model 67 can economically and efficiently handle huge libraries of data, can be partitioned into separate subsystems for specific jobs, and can work around temporarily disabled components without disturbing critical jobs. These advantages are due in part to the following features and characteristics.

Shared Storage: The duplex Model 67-2 allows shared use of the multiple processor storage units by the two CPU's, making available as many as two million bytes of storage to either unit.

System Partitioning: The duplex model also allows partitioning of the components into separate subsystems for maximum flexibility and availability, achieving this by controls provided on the IBM 2167 Configuration Unit.

Dynamic Address Translation: This combination of advanced programming and circuitry permits each user to program as though he had sole use of a large, contiguously-addressable main storage area of about 16 million or 4 billion bytes, depending on whether the standard or the extended dynamic address translation feature is chosen. This feature may be turned off to permit use of the Model 67 as a Model 65.

Standard Features, Model 67-1

Universal instruction set
Seven-bit storage protect (for the 2067 Processor Unit Model 1)
Attachment for as many as two 2860 Selector Channels
Attachment for one 2870 Multiplexer Channel
24-bit dynamic address translation
Timer (high-resolution type)

Standard Features, Model 67-2

Universal instruction set
Address prefixing (for the 2067 Processing Unit Model 2)
Attachment for the first 2067-2 (for the 2365-12)
Shared storage
Floating storage addressing (for the 2167 Configuration Unit)
Floating channel addressing (for the 2167 Configuration Unit)
Seven-bit storage protect (for the 2067-2)
Attachment for as many as two 2067 Processing Units Model 2
Attachment for as many as eight units of 2365 Processor Storage Model 12 (for the 2846)
Attachment for a 2846 Channel Controller (one per 2067-2)
24-bit dynamic address translation
Partitioning sensing (for the 2167 Configuration Unit)
Timer (high-resolution type)

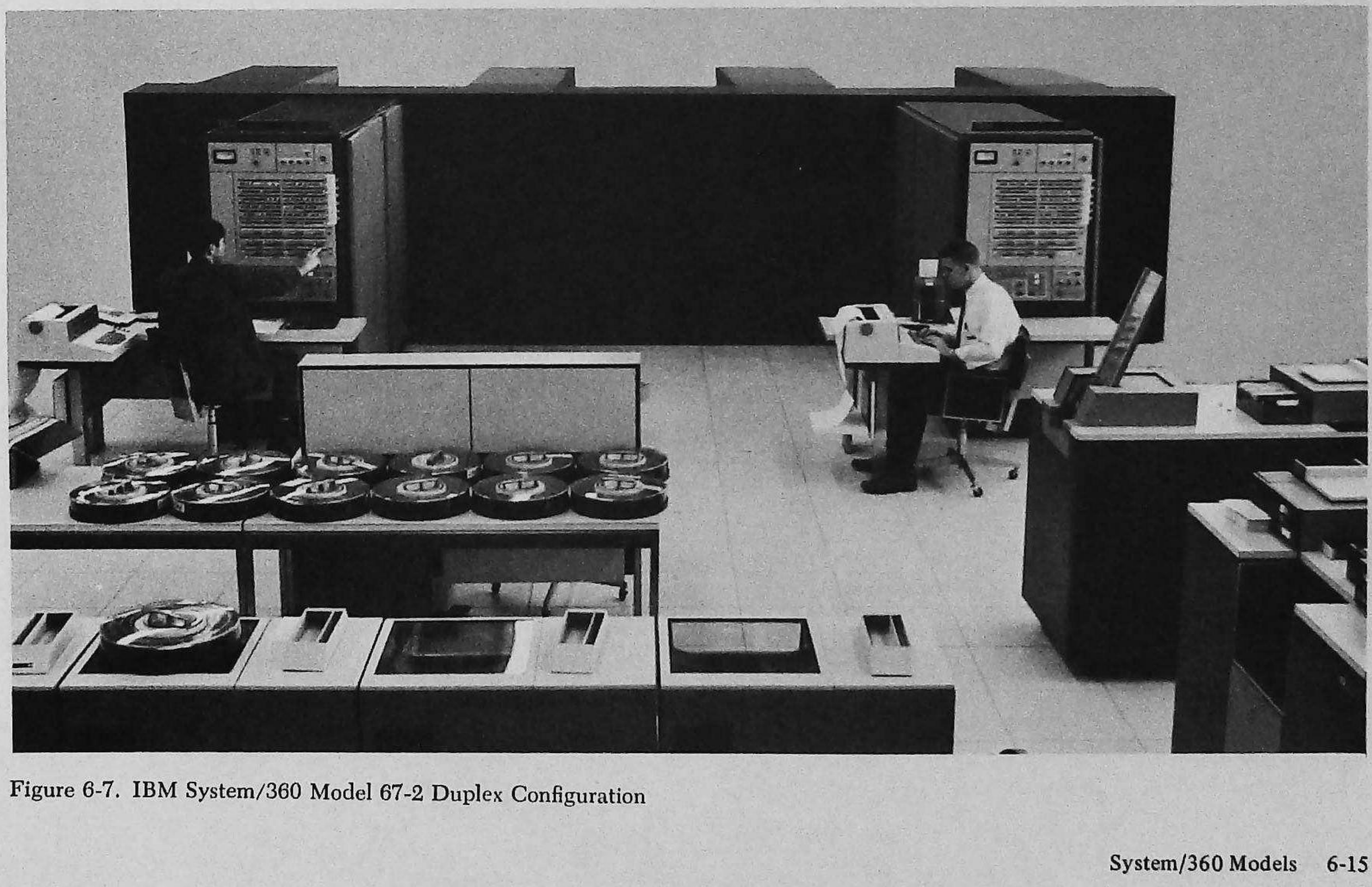


Figure 6-7. IBM System/360 Model 67-2 Duplex Configuration

Optional Features, Model 67-1

Floating storage addressing
High-speed, direct-access storage priority (for the first selector channel)
Expansion feature (for 2365 Processor Storage Model 2)
Seven-bit storage protect (for the 2365 Processor Storage Model 2)
2860 Selector Channel (providing as many as six selector channels)
2870 Multiplexer Channel (as many as two)
Selector subchannels (as many as four on the first 2870, as many as two on a second one.
Channel-to-channel adapter
Direct control (includes external interrupt)
709/7040/7044/7090/7094/7094 II compatibility
Extended dynamic address translation
Adapter for 1052 Printer-Keyboard Model 7

Optional Features, Model 67-2

Address prefixing (one for each channel on the duplex Model 67-2)
Additional addressing, types I and II (for each 2846 Channel Controller)
High-speed, direct-access storage priority (used only on the first selector channel)
2846 switching feature (as many as two)
Expansion feature
Power sequencing
2067 switching feature
2860 Selector Channel (as many as two units per 2846)
2870 Multiplexer Channel (one per 2846)
Selector subchannels (as many as four)
Channel-to-channel adapter
Additional attachment for the 2846 Channel Controller
Extended direct control (includes external interrupt)
709/7040/7044/7090/7094/7094 II compatibility
Partitioning sensing (for the 2067 Processing Unit Model 2)
Extended dynamic address translation
Adapter for the 1052 Printer-Keyboard Model 7
Second wall section attachment

System Components

Central Processing Unit: IBM 2067 Processing Unit Models 1 and 2

One 2067-1 is available with the Model 67-1, but one to two 2067-2's are available with the Model 67-2.

Basic Machine Cycle Time: 0.2 microsecond (200 nanoseconds).

Instruction Set: The universal instruction set is standard with the Model 67.

Control Signal Exchange and External Interruption: The direct control feature is optional on the Model 67-1, and the extended direct control feature, which permits the direct communication of control information between two CPU's, is used on the duplex Model 67-2. Each CPU in a duplex system must be equipped with this feature. Both control features include the external interrupt feature.

Dynamic Address Translation: This combination of advanced programming and circuitry permits each user to program as though he had sole use of a large, contiguously-addressable main storage area of about 16 million or 4 billion bytes, depending on whether the standard or the extended dynamic address translation feature is chosen.

Partitioning Sensing: This feature, required on each CPU of a duplex Model 67-2, allows the program to sense the status of all partitioning switches of the 2167 Configuration Unit.

Floating Storage Addressing: This feature provides the Model 67-1 with the capability of changing the addressing of 2365 Processor Storage Model 2's.

Main Storage: IBM 2365 Processor Storage Models 2 and 12

As many as four 2365-2's are available with the Model 67-1 and as many as eight 2365-12's with the Model 67-2.

Storage Sizes:

CAPACITY (BYTES)	MODEL
262,144	67-1, 67-2
524,288	67-1, 67-2
786,432	67-1, 67-2
1,048,576	67-1, 67-2
1,310,720	67-2
1,572,864	67-2
1,835,008	67-2
2,097,152	67-2

Storage Cycle Time: 0.75 microsecond.

Storage Access Width: Eight bytes (one dblwd).

Storage Interleaving: Two-way.

Protection Features: The seven-bit storage protect feature expands the standard fetch protection to accommodate the dynamic address translation feature. One such protection feature is required on each 2365-2; it is standard on the 2365-12.

Shared Storage: The duplex Model 67-2 allows shared use of the multiple processor storage units by the two CPU's, making as many as 2,097,152 bytes of storage available to either unit.

IBM 2167 Configuration Unit

The 2167 Configuration Unit contains:

1. The partitioning switches and lights for the 2067 Processing Unit Model 2's, 2365 Processor Storage Model 12's and 2846 Channel Controllers.
2. The switches for the I/O control units.

Included also are the floating addressing controls (for both channels and storage) and the partitioning sensing feature.

IBM 2846 Channel Controller

This unit (used only with the Model 67-2) provides the system with increased accessibility to auxiliary storage devices, especially useful in time-sharing applications. In the duplex Model 67-2, it provides:

1. Communication between the CPU's and the channels controlling the auxiliary storage devices.
2. Data paths for control information and data transfers between main storage and the channels.

The basic 2846 allows for the attachment of as many as four units of 2365 Processor Storage Model 12; the additional addressing features (I and II) increase this number to eight, permitting the 2846 to address over 2 million bytes of main storage. Also, as many as two 2846's may be attached to a Model 67-2 permitting as many as 14 channels (12 selector and 2 byte multiplexer) in a system.

Channels: IBM 2860 Selector Channel Models 1-3 and 2870 Multiplexer Channel

The Model 67 can have as many as seven channels per CPU (six selector and one byte multiplexer, or alternatively for the Model 67-1, five selector and two byte multiplexer) but requires at least one channel of either type.

The 2870 Multiplexer Channel provides the Model 67 with subchannels:

	BYTE MULTIPLEXER SUBCHANNELS	SELECTOR SUBCHANNELS (OPTIONAL)
First 2870	192	up to four
Second 2870 (on 67-1 only)	192	up to two

With the Model 67-2, one 2846 Channel Controller attachment feature is standard, and a second is optional. Each 2846 can attach one 2870 and two 2860's; at least one 2860 or 2870 is required. Therefore, with two 2846's, two byte multiplexer channels can be available; only one of these channels may have more than eight control units or have selector subchannels. The duplex Model 67-2 also requires the address prefixing feature on each channel.

Interchannel Connections: The channel-to-channel adapter is used to interconnect two System/360 channels. On the Model 67, an adapter can be attached for each of the selector channels, permitting each of them to communicate with either a byte multiplexer channel or with another selector channel. The use of an adapter requires one control-unit position on each of the connected channels.

System

Compatibility Feature: The 709/7040/7044/7090/7094/7094 II compatibility feature may be installed on both the Model 67-1 and the Model 67-2.

System Control: The Model 67 has one system control panel per CPU. Each one provides for the operation, monitoring, and control of the CPU on which it is mounted. A remote operator control panel is also available for each CPU, and each panel duplicates the CPU-mounted operator controls and may be mounted on a 2150 Console.

Programming Support

The Model 67 can operate in either a standard mode under DOS, TOS, or OS, or a time-sharing mode under the Time-Sharing System (TSS). While operating under TSS, the Model 67 is capable of doing conversational-interactive computing together with batch processing on a time-shared basis. TSS takes advantage of the capabilities of a multiprocessor system and performs dynamic relocation of problem programs by using the dynamic address translation facilities of the 2067 Processing Unit. (See "Dynamic Address Translation" discussed previously in this model description.)

In the conversational-interactive mode, TSS uses a 2741 Communication Terminal as a remote terminal for such operations as one-line program development and testing, problem solving, and data entry and display.

System/360 Model 75

The System/360 Model 75 (Figure 6-8) is a significant step higher in efficiency and speed of internal processing than the Model 65. The primary advantages of the Model 75 are: shorter instruction execution times (approximately two times shorter than the Model 65) and overlapping of processing (two instructions processed concurrently). The Model 75 has a maximum main storage capacity of 1,048,576 bytes, which can be supplemented by an additional one to eight million bytes of 2361 Core Storage (LCS). The effective speed of storage access is increased by the use of two- and four-way interleaving (two-way only for LCS).

Standard Features

Universal instruction set
Storage protection (both store and fetch protection)
Attachment for 2870 Multiplexer Channel
Attachment for 2860 Selector Channel
Direct control (includes external interrupt)
Timer (line-frequency type)

Optional Features

2361 Core Storage (LCS) with attachment
Shared LCS
2860 Selector Channel (providing as many as six selector channels)
2870 Multiplexer Channel (as many as two)
Selector subchannels (as many as four on the first 2870, as many as two on a second one)
Adapter for 1052 Printer-Keyboard Model 7 (as many as two)

System Components

Central Processing Unit: IBM 2075 Processing Unit

Basic Machine Cycle Time: 0.195 microsecond (195 nanoseconds).

Instruction Set: The universal instruction set is standard with the Model 75.

Control Signal Exchange and External Interruption: The direct control feature is standard on the Model 75 and includes the external interrupt feature.

Main Storage: IBM 2365 Processor Storage Model 3; IBM 2361 Core Storage Models 1 and 2 (Optional)

Storage Sizes:

CAPACITY (BYTES)	MODEL	STORAGE UNITS	TYPE OF INTERLEAVING
262,144	H	One 2365-3	Two-way
524,288	I	Two 2365-3's	Four-way
786,432	IH	Three 2365-3's	Two-way
1,048,576	J	Four 2365-3's	Four-way

Storage Cycle Time: 0.75 microsecond.

Storage Access Width: Eight bytes (one doubleword).

Protection Features: Both store and fetch protection are standard on the Model 75.

Large-Capacity Storage (2361 Core Storage):

	NUMBER OF 2361-1's	NUMBER OF 2361-2's
Without interleaving	1	1 to 4*
With interleaving	2	2 to 4*

*If the system has two 2860's and two 2870's, the maximum number of 2361's permitted is three rather than four.

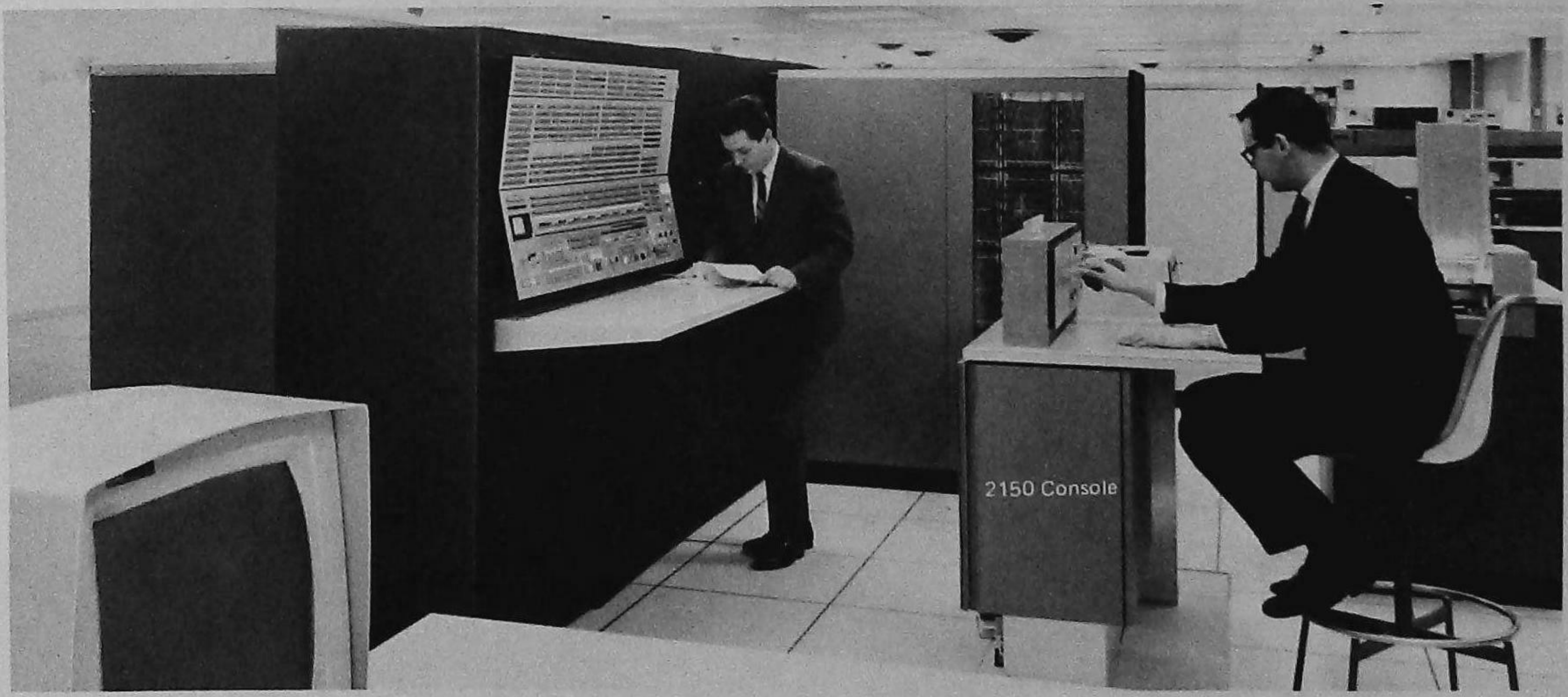


Figure 6-8. IBM System/360 Model 75 with IBM 2150 Console

Channels: IBM 2860 Selector Channel Models 1-3 and 2870 Multiplexer Channel

The Model 75 can have as many as seven channels (six selector and one byte multiplexer, or five selector and two byte multiplexer) but requires at least one.

The 2870 Multiplexer Channel provides the Model 75 with subchannels:

	BYTE MULTIPLEXER SUBCHANNELS	SELECTOR SUBCHANNELS (OPTIONAL)
First 2870	192	up to 4
Second 2870	192	up to 2

Interchannel Connection: The channel-to-channel adapter is used to interconnect two System/360 channels. On the Model 75, an adapter can be attached for each of the selector channels, permitting each to communicate with either a byte multiplexer channel or with another selector channel. The use of an adapter requires one control-unit position on each of the connected channels.

System

System Control: The Model 75 is operated, monitored, and controlled via the system control panel on the 2075 Processing Unit. A remote operator control panel is also available which can duplicate the operator control section of the system control panel and may be mounted on a 2150 Console or a 2250 Display Unit Model 1.

Programming Support

The Model 75 is supported by BPS, BOS, DOS, TOS, and OS.

System/360 Model 195

The System/360 Model 195 is an ultrahigh-performance data processing system designed for high-speed large-scale scientific and commercial applications. Its scientific applications range from nuclear physics to weather forecasting and theoretical astronomy. In commercial applications, the Model 195 can be used, for example, as the control center of the most complex airline reservation systems, coast-to-coast time-sharing networks, or process control systems.

The power and speed of this advanced system are primarily the result of:

1. Improved circuit technology.
2. High performance of buffer storage for main storage accesses.
3. Buffering within the processor.
4. Very fast execution times.
5. A high degree of concurrency in operation.
6. Highly efficient algorithms, particularly in floating-point operations.

Circuitry: The logic circuits in the Model 195 use monolithic technology. These advanced circuits have a basic delay time of less than 5 nanoseconds, as compared with delay times of 5 to 30 nanoseconds for SLT circuits used in most other System/360 models. Also, the monolithic packaging densities are many times those of SLT circuitry; boards approximately 8 by 12 inches contain as many as 4,000 circuits.

Parallel Processing: Processing proceeds concurrently in five separate highly autonomous units: main storage, the storage control unit and buffer storage, the instruction processor, the fixed-point/variable-field-length/decimal processor, and the floating-point processor. Furthermore, each unit may be performing several functions at one time. In the floating-point processor, for example, as many as three floating-point operations may be executed concurrently.

Standard Features

Universal instruction set
High-speed buffer storage
Extended-precision floating-point
Byte-oriented operands
Storage protection (both store and fetch protection)
Attachment for 2860 Selector Channel
Attachment for 2870 Multiplexer Channel
Attachment for 2880 Block Multiplexer Channel
Direct control (includes external interrupt)
Interval timer (9.6 kHZ–about a 104-microsecond interval)
System console
Remote operator control panel attachment
Emergency power-off control

Optional Features

2860 Selector Channel (providing as many as six selector channels)
2870 Multiplexer Channel (as many as two)
Selector subchannels (as many as four on the first 2870, as many as two on a second one)
2880 Block Multiplexer Channel (providing as many as six block multiplexer channels per CPU)
Channel-to-channel adapter
2150 Remote Operator Console

System Components

Central Processing Unit: 3195 Processing Unit

Basic Machine Cycle Time: 0.054 microsecond (54 nanoseconds).

Instruction Set: The universal instruction set is standard on the Model 195.

Control Signal Exchange and External Interruption: The direct control feature is standard on the Model 195 and includes the external interrupt feature.

Main Storage: Part of 3195 Processing Unit

Storage Sizes:

CAPACITY (BYTES)	PROCESSOR MODEL	TYPE OF INTERLEAVING
1,048,576	J	8-way
2,097,152	K	16-way
3,145,728	KJ	8- or 16-way
4,194,304	L	16-way

Storage Cycle Time: 0.756 microsecond.

Storage Access Width: Eight bytes (one doubleword).

High-Speed Buffer Storage: Most storage accesses are satisfied by this 32K-byte buffer storage, which in effect reduces the access time of most main storage accesses from 810 nanoseconds to 162. The buffer storage is controlled by an algorithm implemented in monolithic circuitry, thus its function is transparent to the programmer.

Storage Control Unit: This unit is the intermediary between main storage and the other system units. As such, it controls the accesses to the high-speed buffer storage and to main storage.

Channels: IBM 2860 Selector Channel Models 1-3, 2870 Multiplexer Channel, and 2880 Block Multiplexer Channel Models 1 and 2

The Model 195 can have as many as seven channels per CPU, contained within three to seven channel units (2860, 2870, and 2880 frames). The maximum combination of channels can be either:

1. One byte multiplexer channel and six selector and/or block multiplexer channels.

2. Two byte multiplexer channels and five selector and/or block multiplexer channels.

At least one channel is required. If the one channel is a 2870, it must have at least one selector subchannel.

Both the first and second 2870 have 192 byte multiplexer subchannels. The first 2870 can additionally have four selector subchannels, and a second 2870 can have two.

Interchannel Connection: A channel-to-channel adapter can be attached for each selector channel on the Model 195, permitting each selector channel to communicate with a byte or block multiplexer channel or with another selector channel. This adapter uses one control-unit position on each of the two channels.

System

System Control: The system controls are located on a stand-alone system console (considered part of the CPU). Integrated with the system console is a display console (similar to a 2250 Display Unit Model 1), which provides the operator with visual two-way communication with the system. The operator controls can also be duplicated at a remote panel on a 2150 Console.

Programming Support

The Model 195 is supported by a subset of OS with MVT.

Features and Characteristics	Application on Models									
	22	25	30	40	44	50	65	67	75	195
Central Processing Unit (CPU)										
CPU Model Number	2022	2025	2030	2040	2044	2050	2065	2067	2075	3195
Basic Machine Cycle Time (nanoseconds)	750	900	750	625	250	500	200	200	195	54
Instruction Sets										
Standard (Std)	std	–	std	std	std ⓐ	–	–	–	–	–
Commercial (Std and Decimal Arithmetic)	std	std	opt	opt	opt ⓐ	–	–	–	–	–
Scientific (Std and Floating-Point Arithmetic)	opt	opt	opt	opt	opt ⓐ	–	–	–	–	–
Universal (Std, Dec Arith, Floating-Point Arith, and Storage Protection)	opt	opt	opt	opt	opt ⓐ	std	std	std	std	std
Direct Control	–	opt	opt	opt	–	opt	opt	opt	std	std
Extended Direct Control (for Duplex Model 67-2)	–	–	–	–	–	–	–	opt	–	–
Direct Word	–	–	–	–	opt	–	–	–	–	–
Extended-Precision Floating-Point Arithmetic	–	–	–	–	–	–	–	–	–	std
Variable Long-Precision Floating-Point Arithmetic	–	–	–	–	opt	–	–	–	–	–
Byte-Oriented Operand	–	–	–	–	–	–	–	–	–	std
External Interrupt	opt	opt	opt	–	opt	–	–	–	–	–
Priority Interrupt	–	–	–	–	opt	–	–	–	–	–
High-Speed Buffer Storage	–	–	–	–	–	–	–	–	–	std
Dynamic Address Translation	–	–	–	–	–	–	–	std	–	–
Time Sharing	–	–	–	–	–	–	–	yes	–	–
Timer										
Line-Frequency Type	opt	opt	opt	std	std	std	std	–	std	–
High-Resolution Type	–	–	–	–	opt	–	–	std	–	std
Storage										
Storage Access Width (Number of Bytes Fetched per Access)	1	2	1	2	4	4	8	8	8	8
Storage Cycle Time (Microseconds)	1.5	1.8	1.5 ⓑ	2.5	1.0	2.0	0.75 ⓒ	0.75 ⓒ	0.75 ⓒ	0.756 ⓒ
Storage Interleaving	–	–	–	–	–	–	2-way	2-way	2 or 4-way	8 or 16-way
Store Protection	opt	opt	opt	opt	opt ⓓ	std	std	std	std	std
Fetch Protection	–	–	–	–	opt ⓓ	–	std	std	std	std
Shared Storage	–	–	–	–	–	–	opt	std on 67-2	–	–
Large-Capacity Storage (LCS) (2361 Core Storage)	–	–	–	–	–	opt	opt	–	opt	–
Shared LCS	–	–	–	–	–	opt ⓔ	opt ⓔ	–	opt ⓔ	–
Main Storage Capacities (in Bytes) ⓕ (Entries are Model Prefixes or Suffixes)										
16,384 = D	–	D	D	–	–	–	–	–	–	–
24,576 = DC	DC	DC	DC	–	–	–	–	–	–	–
32,768 = E	E	E	E	E	E	–	–	–	–	–
49,152 = ED	–	ED	–	–	–	–	–	–	–	–
65,536 = F	–	–	F	F	F	–	–	–	–	–
131,072 = G	–	–	–	G	G	G	–	–	–	–
196,608 = GF	–	–	–	GF	–	–	–	–	–	–
262,144 = H	–	–	–	H	H	H	H	–1, –2	H	–
393,216 = HG	–	–	–	–	–	HG	–	–	–	–
524,288 = I	–	–	–	–	–	I	I, MP	–1, –2	I	–
786,432 = IH	–	–	–	–	–	–	IH, MP	–1, –2	IH	–
1,048,576 = J	–	–	–	–	–	–	J, MP	–1, –2	J	J
1,310,720	–	–	–	–	–	–	MP	–2	–	–
1,572,864	–	–	–	–	–	–	MP	–2	–	–
1,835,008	–	–	–	–	–	–	MP	–2	–	–
2,097,152 = K	–	–	–	–	–	–	MP	–2	–	K
3,145,728 = KJ	–	–	–	–	–	–	–	–	–	KJ
4,194,304 = L	–	–	–	–	–	–	–	–	–	L
Compatibility Features (Entries are Model Prefixes or Suffixes)										
1401/1440/1460 DOS	–	DC, E, ED	DC, E, F	all	–	–	–	–	–	–
1401/1440/1460 Relocatable DOS	–	–	–	all	–	–	–	–	–	–
1401/1460	–	all	all	all but E	–	–	–	–	–	–
1410/7010	–	–	–	all but E	–	all	–	–	–	–
1440	–	all	all	–	–	–	–	–	–	–
1620	–	–	all	–	–	–	–	–	–	–
7070/7074	–	–	–	–	–	H, HG, I	all	–	–	–
7080	–	–	–	–	–	–	all	–	–	–
709/7040/7044/7090/7094 II	–	–	–	–	–	–	I, IH, J, MP	–1, –2	–	–
709/7090/7094/7094 II	–	–	–	–	–	–	–	–	–	–
Model 20 Mode	–	all	–	–	–	–	–	–	–	–

Figure 6-9. Comparison of IBM System/360 Models (Part 1 of 2)

Features and Characteristics	Application on Models									
	22	25	30	40	44	50	65	67	75	195
Programming Support										
Basic Operating System (BOS)	yes	yes	yes	yes	yes ⓘ	yes	yes	–	yes	–
Basic Programming System (BPS)	yes	yes	yes	yes	yes ⓘ	yes	yes	–	yes	–
Disk Operating System (DOS)	yes	yes	yes	yes	yes ⓘ	yes	yes	yes	yes	–
Model 44 Programming System	–	–	–	–	yes	–	–	–	–	–
Operating System (OS)	–	–	yes	yes	yes ⓘ	yes	yes	yes	yes	yes
Tape Operating System (TOS)	yes	yes	yes	yes	yes ⓘ	yes	yes	yes	yes	–
Time-Sharing System (TSS)	–	–	–	–	–	–	–	yes	–	–
Channels										
Max. No. of Channels per CPU	2	1	3	3	3	4	7	7ⓚ	7	7
With extended Channel Feature	–	–	–	–	–	–	–	–	–	14
Block Multiplexer	–	–	–	–	–	–	–	–	–	6
With Extended Channel Feature	–	–	–	–	–	–	–	–	–	13
Byte Multiplexer	1	1	1	1	1	1	2	2	2	2
Selector	1	1	2	2	–	3	6	6	6	6
Both Byte and Block Multiplexer	–	–	–	–	–	–	–	–	–	7
With Extended Channel Feature	–	–	–	–	–	–	–	–	–	14
Both Byte Multiplexer and Selector	2	1	3	3	–	4	7	7ⓚ	7	7
Direct Data Channel	–	–	–	–	1	–	–	–	–	–
High-Speed Multiplexer Channel	–	–	–	–	2	–	–	–	–	–
Max. No. of Channel Units (Frames) per CPU	–	–	–	–	–	–	4	4	4	7
With Extended Channel Feature	–	–	–	–	–	–	–	–	–	8
2880 Block Multiplexer Channel	–	–	–	–	–	–	–	–	–	6
With Extended Channel Feature	–	–	–	–	–	–	–	–	–	8
2870 Multiplexer Channel (Byte Mpx)	–	–	–		–	–	2	2	2	2
2860 Selector Channel	–	–	–	–	–	–	2	2	2	6
Subchannels ⓖ (Type and No., Std or Opt) (n = nonshared, s = shared)										
Byte Multiplexer, of 1st Byte Mpx Channel										
32 n	–	all	–	E	E	–	–	–	–	–
64 n	–	–	–	F	F, G, H	–	–	–	–	–
96 n	all	–	all	–	–	–	–	–	–	–
128 n	–	–	–	G, GF, H	–	all	–	–	–	–
192 n	–	–	–	–	–	–	all	–1, –2	all	all
224 n	–	–	E, F	–	–	–	–	–	–	–
256 n	–	–	–	–	–	H, I	–	–	–	–
Byte Multiplexer, of 2nd Byte Mpx Channel										
192 n	–	–	–	–	–	–	all	–1, –2	all	all
Block Multiplexer, of Block Mpx Channels										
56 n (Max., with 1 s)	–	–	–		–	–	–	–	–	all
64 n (Max., with 0 s)	–	–			–	–	–	–		all
Selector, of 1st Byte Mpx Channel										
4 s	–	–	–	–	–	–	all	–1	all	all
8 s	–	–	–	–	–		–	2	–	–
Selector, of 2nd Byte Mpx Channel										
2 s	–	–	–	–	–	–	H, I, IH, J	–1	all	all
Channel-to-Channel Adapter ⓗ	–	–	opt	opt	–	opt	opt	opt	opt	opt

std = standard
opt = optional
– = not applicable

Notes:

ⓐ The Model 44 instruction set is a selection of instructions from the System/360 standard instruction set. Adding floating-point arithmetic provides the Model 44 with a scientific instruction set, adding the commercial feature enables the Model 44 to execute all the instructions available in the standard and commercial instruction sets; and adding floating-point arithmetic, the commercial feature, and storage protection in effect provides the Model 44 with the universal instruction set.

ⓑ Main storage cycle time for some earlier Model 30's is 2.0 microseconds.

ⓒ The storage cycle times given for Models 65-195 do not reflect the time reductions that are due to storage interleaving or, additionally for Model 195, the time reduction resulting from the use of the high-speed buffer.

ⓓ Store and fetch protection are not separately available in the Model 44.

ⓔ A Model 50 can share LCS with any other Model 50 or with a Model 65 or 75 of equal or larger storage capacity. A Model 65 or 75 can share LCS with any other Model 65 or 75 of equal storage capacity or with a Model 50 with equal or less capacity.

ⓕ The letters shown with the storage capacities are the model prefixes designating these capacities.

ⓖ Shared subchannels can control several I/O devices or modules having a common control unit; nonshared subchannels can control only one I/O device.

ⓗ For Models 30, 40, and 50, one channel-to-channel adapter may be installed per CPU. For Models 22, 25, and 44, interchannel connection may be made with another system if the adapter is installed on the other system. On Models 65-195, an adapter may be installed for each selector channel installed.

ⓘ BPS, BOS, DOS, TOS, and OS programs can be run on a Model 44 equipped with the commercial feature.

ⓚ The Model 67-2 can have as many as 14 channels (12 selector and two byte multiplexer) because it can have two 2846 Channel Controllers, each capable of controlling up to six selector channels and one byte multiplexer channel.

Figure 6-9. Comparison of IBM System/360 Models (Part 2 of 2)

Section 7. Input/Output Devices

A System/360 at any specific installation consists of a central processing unit, main storage, one or more I/O channels, and all online I/O equipment. Online means that the I/O equipment operates under program control. The following I/O devices and control units, arranged by category, can operate online as part of System/360. Most are briefly described in this section.

Direct Access Devices

2301 Drum Storage
2303 Drum Storage
2305 Fixed Head Storage Models 1 and 2
2311 Disk Storage Drive
2312 Disk Storage Model A1
2313 Disk Storage Model A1
2314 Storage Control Models A1 and B1
2314 A-Series and B-Series Direct Access Storage Facility
2318 Disk Storage Model A1
2319 Disk Storage Models B1 and B2
2321 Data Cell Drive
2820 Storage Control
2835 Storage Control Models 1 and 2
2841 Storage Control
2844 Auxiliary Storage Control
3330 Disk Storage Model 1
3333 Disk Storage and Control Model 1
3830 Storage Control Models 1 and 2
Single-Disk Storage Drive

Display Devices

2250 Display Unit Models 1 and 3
2840 Display Control Model 2
2260 Display Station Models 1 and 2
2848 Display Control Models 1-3, 21, 22
3272 Control Unit Models 1 and 2
3277 Display Station Models 1 and 2

Magnetic Character Readers

1255 Magnetic Character Reader Models 1-3
1259 Magnetic Character Reader Model 2
1419 Magnetic Character Reader

Magnetic Tape Devices

2401 Magnetic Tape Unit Models 1-6 and 8
2803 Tape Control Models 1, 2, and 3
2804 Tape Control Models 1, 2, and 3
2415 Magnetic Tape Unit and Control Models 1-6
2420 Magnetic Tape Unit Models 5 and 7
2816 Switching Unit Model 1
3410 Magnetic Tape Unit Models 1, 2, and 3
3411 Magnetic Tape Unit and Control Models 1, 2, and 3
3420 Magnetic Tape Unit Models 3, 5, and 7
3803 Tape Control Model 1

Magnetic Tape Cartridge Devices

2495 Tape Cartridge Reader

Manual Controls

1052 Printer-Keyboard Models 3, 5, 7, and 8
1051 Control Unit Models 1 and N1

Optical Readers

1231 Optical Mark Page Reader Model N1
1287 Optical Reader Models 1-5
1288 Optical Page Reader

Printers

1053 Printer Models 1 and 4
1403 Printer Models 2, 7, and N1
1404 Printer Model 2
1443 Printer Model N1
1445 Printer Model N1
2821 Control Unit Models 1-6
3211 Printer
3811 Printer Control Unit

Punched Card Devices

1442 Card Read Punch Model N1
1442 Card Punch Model N2
2501 Card Reader Models B1 and B2
2520 Card Read Punch Model B1
2520 Card Punch Models B2 and B3
2540 Card Read Punch
2560 Multi-function Card Machine Model A1
2596 Card Read Punch
3505 Card Reader Models B1 and B2
3525 Card Punch Models P1, P2, and P3

Punched Tape Devices

1017 Paper Tape Reader Models 1 and 2
1018 Paper Tape Punch
2671 Paper Tape Reader
2822 Paper Tape Reader Control
2826 Paper Tape Control Models 1 and 2

Extensive attachment information for the I/O devices and control units is given in Figure 7-1.

Attachment information for devices or subsystems used in teleprocessing, data acquisition, or process control is given in Figure 8-1.

Input/Output (I/O) Device or Control Unit			Attaches to	Means of Attachment to System/360 Model										No. of I/O Devices or Lines Attachable
No.	Models	Name		22	25	30	40	44	50	65	67	75	195	
1017	1,2	Paper Tape Reader	2826	m	m	m	m	–	m	–	–	–	–	ⓩ
1018	1	Paper Tape Punch	2826	m	m	m	m	–	m	–	–	–	–	ⓩ
1051	1, N1	Control Unit	→	See 1052 and 1053										ⓑ
1052	3	Printer-Keyboard	1051-1	–	–	a	–	–	–	–	–	–	–	1 per 1051
	5,6*	Printer-Keyboard	1051-N1	–	–	a	–	–	–	–	–	–	–	1 per 1051
	7	Printer-Keyboard	2150 Console	–	–	–	–	–	ms	msx	msx	msx	bmsx	1 per 2150
			CPU Adapter	–	–	–	m	–	m	ms	ms	ms	–	1 per system ⓢ
			→	–	i	–	–	–	–	–	–	–	–	1 per system
	8	Printer-Keyboard	1051-N1	–	–	a	–	–	–	–	–	–	–	1 per system
			→	i	–	–	–	–	–	–	–	–	–	1 per system
1053	1	Printer	1051-1,-N1	–	–	a	–	–	–	–	–	–	–	2 per 2051
	4	Printer	2848-1-3,-21,-22	ms	ms	ms	ms	mh	ms	msx	ms	msx	bmsx	1 per 2848
1231	N1	Optical Mark Page Reader	→	ms	ms	ms	ms	–	ms	–	–	–	–	4 per system
1255	1-3	Magnetic Character Reader	S/360/370 Adapter	ms	ms	ms	ms	–	ms	–	–	–	–	1 per system
1259	2	Magnetic Character Reader	→	m	ms	m	m	–	–	–	–	–	–	1 per system
1287	1-5	Optical Reader	→	ms	ms	ms	ms	–	ms	mx	mx	mx	–	ⓓ
1288	1	Optical Page Reader	→	ms	ms	ms	ms	–	ms	mx	mx	mx	–	ⓓ
1403	2, N1	Printer	2821-1,-2,-3,-5	ms	ms	ms	ms	mh	ms	msx	m	msx	bmsx	ⓥ
	2,7,N1	Printer	CPU Adapter	–	i	–	–	–	–	–	–	–	–	1 per system
	7	Printer	2821-1,-2,-3,-5	ms	ms	ms	ms	mh	ms	msx	m	msx	bmsx	ⓥ
1404	2	Printer	2821-4	–	ms	ms	ms	–	ms	–	–	–	–	ⓥ
1419	1	Magnetic Character Reader	S/360 Adapter (#7720)	ms	ms	ms	ms	–	ms	msx	msx	–	–	ⓓ
			S/360 Adapter (#7730)	m	m	m	m	–	m	m	–	–	–	ⓓ
1442	N1	Card Read Punch	→	ms	ms	ms	ms	mh	ms	msx	msx	msx	bmsx	ⓒ
	N2	Card Punch	→	ms	ms	ms	ms	mh	ms	msx	msx	msx	–	ⓓ
1443	N1	Printer	→	ms	ms	ms	ms	mh	ms	msx	msx	msx	bmsx	ⓓ
1445	N1	Printer	→	–	ms	ms	–	–	–	–	–	–	–	ⓓ
1800	–	Data Acquisition and Control System	S/360 Adapter	ms	m	ms	ms	mh	ms	–	–	–	–	ⓕ
			1827	m	m	m	m	mh	m	–	–	–	–	ⓕ
1827	1	Data Control Unit		See 1800										ⓕ
2250	1	Display Unit	→	ms	–	ms	ms	mh	ms	sx	sx	sx	bsx	ⓓ
	3	Display Unit	2840-2	ms	–	ms	ms	mh	ms	sx	sx	sx	bsx	4 per 2840
2260	1	Display Station	2848-3	ms	ms	ms	ms	mh	ms	msx	msx	msx	bmsx	8 per 2848
	2	Display Station	2848-1,-2,-21,-22	ms	ms	ms	ms	mh	ms	msx	msx	msx	bmsx	ⓧ
2301	1	Drum Storage	2820	–	–	–	–	–	–	s	s	s	bs	4 per 2820
2303	1	Drum Storage	2841	–	–	–	s1/2	–	s	sx	sx	sx	bs	2 per 2841 ⓦ
2305	1	Fixed Head Storage ⓞ	2835-1	–	–	–	–	–	–	–	–	–	b	2 per 2835
	2	Fixed Head Storage ⓞ	2835-2	–	–	–	–	–	–	–	–	–	b	2 per 2835
2311	1	Disk Storage Drive	2841	ms	–	ms	ms	mh	ms	sx	sx	sx	bs	8 per 2841 ⓦ
			→	–	i	–	–	–	–	–	–	–	–	4 per system
2312	A1	Disk Storage	2314-A1	See 2314–A Series										ⓗ
2313	A1	Disk Storage	2314-A1	See 2314–A Series										ⓗ
2314	A-Series	Direct Access Storage Facility ⓗ	2844 ⓘ	–	–	s1 ⓠ	s1/2 ⓠ	–	s	s	s	s	bs	1 per 2844
			→	–	–	s1 ⓠ	s1/2 ⓠ	–	s	s	s	s	bs	ⓓ
	B-Series	Direct Access Storage Facility	→	–	–	s1 ⓠ	s1/2 ⓠ	–	x	x	x	x	bs	ⓙ
2314	A1	Storage Control	→	See 2314–A Series										ⓗ
	B1	Storage Control	→	See 2314–B Series										9 modules ⓙ
2318	A1	Disk Storage	2314-A1	See 2314–A Series										9 modules ⓗ
2319	B1	Disk Stroage	2314-B1	See 2314–B Series										ⓙ
	B2	Disk Storage	2314-B1	See 2314–B Series										ⓙ
2321	1	Data Cell Drive	2841	ms	–	ms	ms	–	ms	sx	sx	sx	bsx	8 per 2841 ⓦ
2401	1,2	Magnetic Tape Unit	2803-1,-2	ms	s	ms	ms	mh	ms	sx	sx	sx	bsx	ⓝ
	1,2	Magnetic Tape Unit	2804-1,-2	ms	–	ms	ms	mh	ms	sx	sx	sx	bsx	
	3	Magnetic Tape Unit	2803/04-1,-2	ms	–	ms	ms	mh	ms	sx	sx	sx	bsx	
	4	Magnetic Tape Unit	2803-2	ms	s	ms	ms	mh	ms	sx	sx	sx	bsx	
	4	Magnetic Tape Unit	2804-2	ms	–	ms	ms	mh	ms	sx	sx	sx	bsx	
	5	Magnetic Tape Unit	2803/04-2	ms	–	ms	ms	mh	ms	sx	sx	sx	bsx	
	6	Magnetic Tape Unit	2803/04-2	–	–	s	s	h	ms	sx	sx	sx	bsx	
	8	Magnetic Tape Unit	2803-3	ms	s	ms	ms	mh	ms	sx	sx	sx	bsx	8 per 2803-3
	8	Magnetic Tape Unit	2804-3	ms	–	ms	ms	mh	ms	sx	sx	sx	bsx	8 per 2804-3

Figure 7-1. I/O Attachment Data (Part 1 of 3)

Input/Output (I/O) Device or Control Unit			Attaches to	Means of Attachment to System/360 Model										No. of I/O Devices or Lines Attachable
No.	Models	Name		22	25	30	40	44	50	65	67	75	195	
2415	1-6	Magnetic Tape Unit and Control	→	ms	s	ms	ms	–	ms	sx	sx	sx	–	ⓓ
2420	5	Magnetic Tape Unit	2803-2	–	–	s	s	h	ms	sx	sx	sx	bsx	ⓝ
	7	Magnetic Tape Unit	2803-2	–	–	–	–	–	s	s	s	s	bs	
2495	1	Tape Cartridge Reader	→	m	ms	m	m	–	m	m	m	m	–	ⓓ
2501	B1,B2	Card Reader	→	ms	ms	ms	ms	mh	ms	msx	msx	msx	bmsx	ⓓ
2520	B1	Card Read Punch	→	ms	ms	ms	ms	mh	ms	msx	msx	msx	bmsx	ⓓ
	B2,B3	Card Punch	→	ms	ms	ms	ms	mh	ms	msx	msx	msx	bmsx	ⓓ
2540	1	Card Read Punch	CPU Adapter	–	i	–	–	–	–	–	–	–	–	1 per system
			2821-1,-5,-6	ms	ms	ms	ms	mh	ms	msx	m	msx	bmsx	ⓥ
			2821-4	ms	ms	ms	ms	–	ms	–	–	–	–	ⓥ
2560	A1	Multi-function Card Machine	CPU Adapter	–	i	–	–	–	–	–	–	–	–	1 per system
2596	1	Card Read Punch	→	ms	ms	ms	ms	–	ms	msx	–	msx	bmsx	ⓓ
2671	1	Paper Tape Reader	2822	ms	ms	ms	ms	mh	ms	–	m	–	–	1 per 2822
2701	1	Data Adapter Unit	→	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx	ⓚ
2702	1	Transmission Control	→	m	m	m	m	m	m	m	m	m	m	ⓚ
2703	1	Transmission Control	→	m	m	m	m	–	m	m	m	m	m	ⓚ
2715	1	Transmission Control Unit	→	See 2790										ⓖ
2790	–	Data Communication System	2715-1	m	m	m	m	–	m	m	m	m	m	–
2803	1,2,3	Tape Control ⓜ	→	See 2401 and 2420										ⓝ
2804	1,2,3	Tape Control ⓜ	→	See 2401										ⓝ
2816	1	Switching Unit	2803-1,-2	See 2401										ⓛ
2820	1	Storage Control	→	See 2301										4 2301's ⓣ
2821	1-6	Control Unit	→	See 1403, 1404, and 2540										ⓥ
2822	1	Paper Tape Reader Control	→	See 2671										1 2671
2826	1	Paper Tape Control	→	See 1017 and 1018										ⓩ
2835	1,2	Storage Control	→	See 2305										2 2305's ⓞ
2840	2	Display Control	→	See 2250-3										4 2250-3's
2841	1	Storage Control	→	See 2303, 2311, and 2321										ⓠ ⓦ
2844	1	Auxiliary Storage Control	→	See 2314-1 and 2314–A Series										1 2314 ⓠ
2848	1-3,21,22	Display Control	→	See 1053-4 and 2260										ⓧ
3211	1	Printer	3811	ms	–	ms	ms	–	ms	msx	m	msx	bmsx	1 per 3811
3270	–	Information Display System	3272	–	ms	ms	ms	–	ms	msx	msx	msx	bmsx	ⓐ
3272	1,2	Control Unit	→	See 3270										
3277	1,2	Display Station	→	See 3270										
3330	1	Disk Storage	3333	–	–	–	–	–	–	–	–	–	b	ⓟ
			3830-1	–	–	–	–	–	–	–	–	–	b	4 per 3830-1
3333	1	Disk Storage and Control	3830-2	–	–	–	–	–	–	–	–	–	b	ⓟ
3410	1	Magnetic Tape Unit	3411-1	ms	s	ms	ms	–	ms	–	–	–	–	3 per 3411-1
	2	Magnetic Tape Unit	3411-2	ms	s	ms	ms	–	ms	–	–	–	–	5 per 3411-2
	3	Magnetic Tape Unit	3411-3	ms	s	ms	ms	–	ms	–	–	–	–	5 per 3411-3
3411	1,2,3	Magnetic Tape Unit and Control	→	ms	s	ms	ms	–	ms	–	–	–	–	ⓓ
3420	3	Magnetic Tape Unit	3803	s	–	s	ms	–	ms	ms	ms	ms	bms	ⓝ ⓒ
	5	Magnetic Tape Unit	3803	s ⓡ	–	s	s	–	s	s	s	s	bs	
	7	Magnetic Tape Unit	3803	–	–	–	–	–	s	s	s	s	bs	
3505	B1,B2	Card Reader	→	–	–	–	–	–	–	–	–	–	bms	ⓓ
3525	P1,P2,P3	Card Punch	3505	–	–	–	–	–	–	–	–	–	bms	ⓓ
3705	A1-D8	Communications Controller	Channel Adapter Type 1	–	–	m	m	–	m	m	m	m	m	255 lines
3803	1	Tape Control	→	See 3420										ⓝ
3811	1	Printer Control Unit	→	See 3211										1 3211
3830	1*,2	Storage Control	→	See 3330 and 3333										ⓓ
7770	3	Audio Response Unit	→	m	m	m	m	–	m	m	–	m	m	ⓨ
7772	3	Audio Response Unit	→	m	m	m	m	–	m	m	–	m	–	8 lines
–	–	Console Printer-Keyboard	CPU Adapter	–	–	–	–	mh1	–	–	–	–	–	1 per system
–	–	Display Console of 3060 System Console	→	–	–	–	–	–	–	–	–	–	bsx	1 per system
–	–	Single-Disk Storage Drive	CPU Adapter	–	–	–	–	mh1	–	–	–	–	–	2 per system

Symbols

a	CPU feature for I/O attachment using the standard I/O interface.
b	Block multiplexer channel (housed within a 2880 Block Multiplexer Channel).
h	High-speed multiplexer channel (Model 44 only).
h1	First high-speed multiplexer channel.
i	Integrated attachment feature.
m	Byte multiplexer channel (CPU-integrated for Models 22-50; housed within a 2870 Multiplexer Channel for Models 65-195).
s	Selector channel (CPU-integrated for Models 22-50; housed within a 2860 Selector Channel for Models 65-195).
s1	First selector channel.
s1/2	First selector channel or second selector channel, but not both.
x	Selector subchannel on 2870 Multiplexer Channel.
→	See the information in the "Means of Attachment" columns.
–	Not applicable.
*	May not be available.

Figure 7-1. I/O Attachment Data (Part 2 of 3)

Notes (Circled Letters)

ⓐ A locally attached 3270 Information Display System has a 3272 Control Unit Model 1 or 2 controlling various combinations of up to 32 units of 3277 Display Station Models 1 and 2, 3284 Printer Models 1-3, and 3286 Printer Models 1 and 2. The 3272-1 controls only model 1 devices, but the 3272-2 controls both model 1 and 2 devices.

ⓑ 1051 attaches I/O units of an IBM 1050 Data Communication System. (See the *IBM SRL Bibliography Supplement–Teleprocessing,* GA24-3089.)

ⓒ The 3803 tape switching features permit switching of as many as 16 3420's among two, three, or four 3803's.

ⓓ No special restrictions; depends on number of available system channel control unit positions and, for some units, on channel loading considerations.

ⓕ A System/360 adapter, housed within an 1826 Data Adapter Unit Model 1 or 2, can connect an 1800 system to a System/360. An 1827 Data Control Unit Model 1, however, can connect only units and special features of an 1800 system (not including an 1801 or 1802 Processor-Controller) to a System/360. (See the *IBM 1827 Control Unit Configurator,* GA22-6872.)

ⓖ The 2715 Transmission Control Unit Model 1, part of the 2790 Data Communication System, can attach a combination of 2790 devices to System/360 for local operation. These devices include the 2791 and 2793 Area Stations, the 2795, 2796, and 2797 Data Entry Units, and the 2798 Guidance Display Unit. With appropriate attachment features and the expanded capability feature, a 2715 can attach as many as 100 area stations, 1,024 data entry units, and 256 guidance display units.

ⓗ A 2314 A-Series Direct Access Storage Facility (DASF) consists of a 2314 Storage Control Model A1 and combinations of Model A1 units of 2312, 2313, and 2318 Disk Storage, forming a single interconnected unit. Each 2312-A1 provides one disk storage drive, each 2313-A1 four drives, and each 2318-A1 two drives. A full-configuration 2314 A-Series, which consists of two 2313's and one 2312, has nine drives (eight active and one spare).

ⓘ The full-configuration 2314 A-Series DASF can have a 2844 as an auxiliary control unit.

ⓙ A 2314 B-Series Direct Access Storage Facility consists of a 2314 Storage Control Model B1, one 2319 Disk Storage Model B1, and up to two units of 2319 Disk Storage Model B2, forming a single interconnected unit having three, six, or nine (eight active, one spare) drives. Each 2319-B1 and -B2 has three disk storage drives.

ⓚ

Unit	*Mode of Half-Duplex Transmission*	*Max No. of Lines*	*At Line Speeds (bps) up to*
2701	Asynchronous	4	600
	Synchronous	2	230,400
2702	Asynchronous	15	600
	Asynchronous	31	200
2703	Asynchronous	176	165
	Asynchronous	72	600
	Synchronous	48	2,400
	Synchronous	24	4,800
3705	Asynchronous	53	2,400
	Asynchronous	255	300
	Synchronous	2	50,000
	Synchronous	188 or 200	600

On the 2701 and 2703, the number and speeds of attachable lines are also functions of the CPU, the channels assigned, and the characteristics of the other devices attached to those channels.
The 2701 can attach up to four parallel data acquisition devices in place of either of its line attachment alternatives.

ⓛ The 2816 permits switching of as many as eight tape drives (2401 Models 1-6 and 2420's) among four 2803's. With a second 2816 and 16-drive addressing, 4, 8, 12, or 16 drives can be switched among two, three, or four 2803's.

ⓜ 2803 is a single-channel control unit; 2804 is a two-channel control unit. A 2804 requires one control-unit position on each of two channels in the same system.

ⓝ Up to eight:
800-bpi drives (2401-1 to -3) per 2803/04-1.
800- and 1600-bpi drives (2401-1 to -6 and 2420-5, -7) per 2803-2.
800- and 1600-bpi drives (2401-1 to -6) per 2804-2.
800- and 1600-bpi drives (3420-3, -5, -7) per 3803-1.
2401-8's per 2803/04-3.

ⓞ One or two modules of 2305 Fixed Head Storage and a 2835 Storage Control form a 2305 Fixed Head Storage facility, a single interconnected unit.

ⓟ Up to two 3333's can attach to a 3830-2. In turn, each 3333 can attach as many as three 3330's, permitting as many as eight drives per 3333.

ⓠ For Models 30 and 40, putting a 2841 and a 2314 (or 2844) on the same system requires that the devices be put on the same channel. Putting a 2314 or 2844 on a Model 30 also puts restrictions on device attachment to the other selector channel.

ⓡ Only for 800-bpi operation.

ⓢ Two 1052's may be attached to Models 65 and 75.

ⓣ System/360 Models 65, 67-1, 75, 195: up to two 2820's to a 2860-1, up to four 2820's to a 2860-2, and up to four 2820's to a 2860-3. No more than two 2820's to any one channel.
System/360 Model 67-2: one 2820 (with one 2301) per 2846; maximum of two 2820's per system with two 2846's.

ⓥ One 1403 and one 2540 per 2821-1.
One 1403 per 2821-2.
Two (or, with a third printer control, three) 1403's per 2821-3.
One 1404 and one 2540 per 2821-4.
Two (or, with a third printer control, three) 1403's and one 2540 per 2821-5.
One 2540 per 2821-6.

ⓦ The basic 2841 can control as many as eight 2311's or (with attachment features) up to eight access mechanisms from the following combinations:
with no 2303: any combination of 2311's and 2321's.
with one 2303: up to seven 2311's and 2321's but no more than three 2311's.
with two 2303's: no 2311's but up to six 2321's.
When a 2841 with one or more 2321's is attached to a selector subchannel of a 2870, no other devices can be attached to that subchannel.

ⓧ 2848-1: up to 24 2260-2's.
2848-2: up to 16 2260-2's.
2848-3: up to 8 2260-1's.
2848-21: up to 24 2260-2's.
2848-22: up to 16 2260-2's.

ⓨ Except for System/360 Model 25, up to 48 lines; for Model 25, up to 32 lines.

ⓩ 2826-1 attaches up to two 1017's plus up to two 1018's; they can operate concurrently.

Figure 7-1. I/O Attachment Data (Part 3 of 3)

Direct Access Devices

The direct access devices provide auxiliary storage that is large and relatively fast. These devices, which can access data directly as well as sequentially, use media such as magnetic disks, magnetic drums, and magnetic-strip data cells. Figures 7-2 through 7-11 show these devices, and Figure 7-11.1 compares their more prominent characteristics.

2301 Drum Storage;
2820 Storage Control

The IBM 2301 Drum Storage provides direct access storage of approximately four million bytes at a data rate of 1.2 megabytes per second. The high data rate is achieved partially by accessing four tracks in parallel rather than a single track, thus the common reference to this as a "parallel file." Data is recorded on and read from the rotating drum serially by half-byte: first the four high-order bits of the byte, then the four low-order bits.

The 2301 is similar to the IBM 2303 Drum Storage in rotational speed and capacity, and resembles it in external appearance (Figure 7-3). The 2301 records data on 800 tracks, divided into 200 addressable groups of four tracks each. Each such conceptual track can contain a single record of 20,483 bytes. Data records can be of variable length and can overflow from track to track. The access-motion time is zero, and the rotational delay to any record averages 8.6 milliseconds.

The IBM 2820 Storage Control provides the capability of attaching up to four 2301 Drum Storage units to a channel, for a total online direct access capacity of more than 16 million bytes or 32 million packed decimal digits and signs per 2820 attached.

The 2820 interprets and executes all control orders received from the channel, and checks the validity of the data transferred to or from the storage devices.

The optional two-channel switch permits switching a 2820 Storage Control between two channels.

Figure 7-2. IBM 2303 Drum Storage

2303 Drum Storage

The IBM 2303 Drum Storage (Figure 7-2) provides direct access storage for 3.91 million bytes on the magnetic surface of a rotating drum. Two 2303's can be attached to each 2841 Storage Control, for total online storage of 7.82 million bytes per 2841.

The drum rotates at almost 3,500 revolutions per minute. Its surface is divided into 800 tracks; each track has a maximum data capacity of 4,892 bytes. The data transfer rate to or from the CPU is 303,800 bytes per second (or 607,600 packed decimal digits and signs).

Because of the assignment of a read/write head to each track, there is no delay in accessing a track. The rotational delay to a specific part of the track averages 8.6 milliseconds.

The 2303 is used for programming systems residence, rapid access to frequently used data, and other auxiliary storage functions.

2305 Fixed Head Storage Models 1 and 2;
2835 Storage Control Models 1 and 2

An IBM 2835 Storage Control with one or two modules of IBM 2305 Fixed Head Storage forms an IBM 2305 Fixed Head Storage facility (Figure 7-3). With its short access time and medium capacity, this facility provides System/360 with disk storage especially well-suited for applications such as programming systems residence and table or index storage.

Two models of the 2305 facility are available:

Model 1 consists of one 2835 Model 1 and one or two 2305 Model 1 modules.

Model 2 consists of one 2835 Model 2 and one or two 2305 Model 2 modules.

The speed and capacities of the 2305 facilities are:

	Model 1	*Model 2*
Storage capacity (rounded, megabytes)	5.4 or 10.8	11.2 or 22.4
Average access time (milliseconds)	2.5	5.0
Data transfer rate (megabytes per second)	3.0	1.5

Both models of the 2305 facility attach to System/360 via a block multiplexer channel. The Model 1 facility, having a data transfer rate of 3.0 million bytes per second, requires a 2880 Block Multiplexer Channel equipped with the two-byte interface feature.

2305 Fixed Head Storage

Each 2305 module has six 14-inch, oxide-coated disks permanently mounted within the module. Each module uses read/write heads having one or two read/write elements per track.

The primary characteristics of the 2305 modules are:

	Model 1	*Model 2*
Number of read/write elements per track	2	1
Number of addressable tracks	384	768
Number of spare tracks	48	96
Bytes per module	5,428,224	11,258,880
Rotation time (milliseconds)	10	10
Access time, maximum (milliseconds)	5.1	10.25
Access time, average (milliseconds)	2.5	5.0
Data transfer rate (megabytes per second)	3.0	1.5

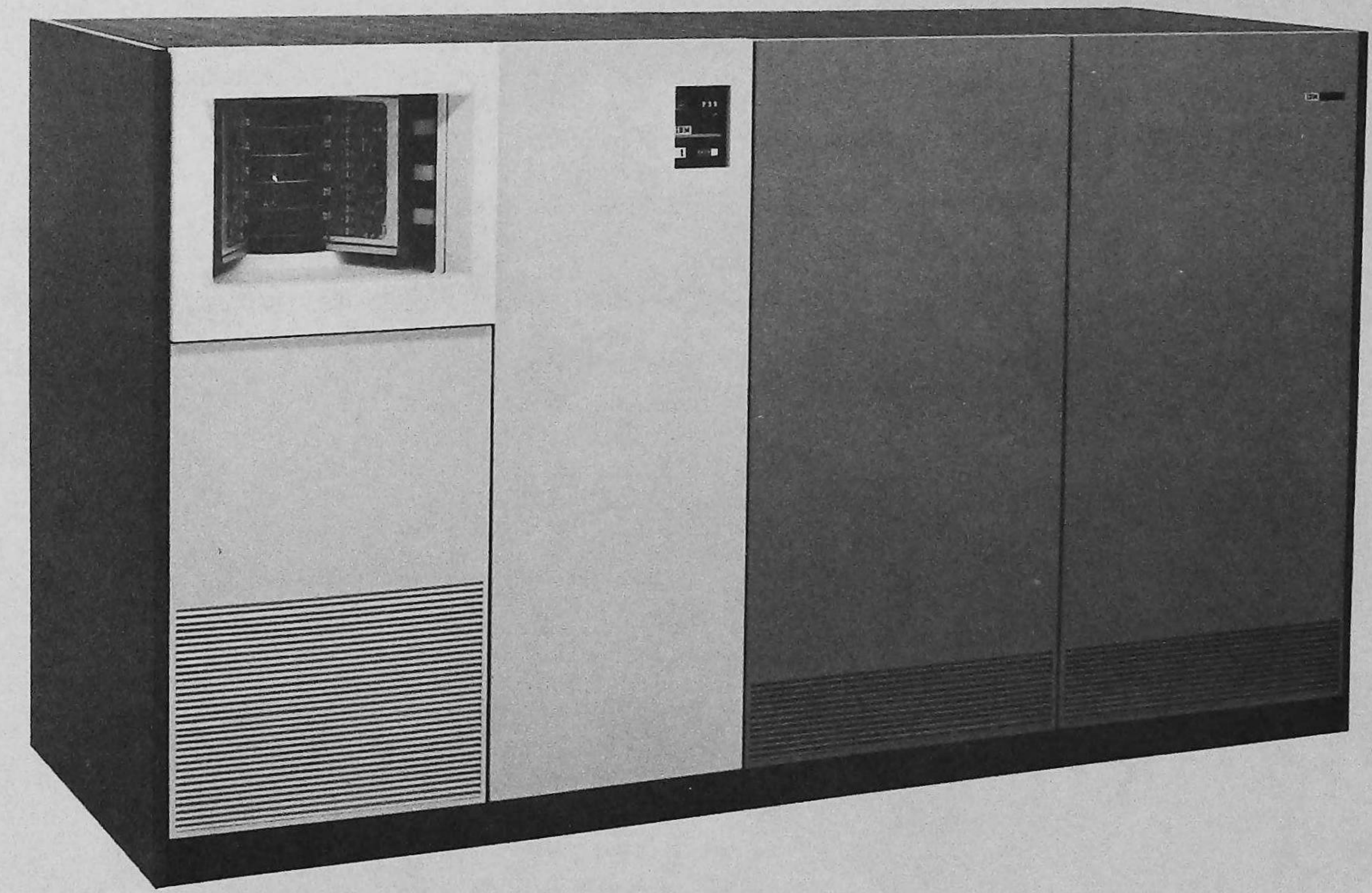


Figure 7-3. IBM 2305 Fixed Head Storage and 2835 Storage Control

2835 Storage Control

The 2835 interprets and executes all channel commands received from the block multiplexer channel. In addition, it provides the 2305 facility with error detection and correction capabilities by adding correction codes to each record.

Related to these capabilities are two methods for verification of data:

Full Read-Back Check: All just-written data is read back into main storage and compared with the original data.

Correction Code Check: The 2835 performs a non-comparative check of data validity, using the correction codes.

The 2835 standard features include:

Command Retry, which enhances error recovery by permitting the channel and control unit to retry operations without CPU program intervention.

Rotational Position Sensing, which increases channel availability by releasing the channel during most of record search time.

Multiple Requesting, which permits up to 16 record requests to be active in the storage facility, thereby permitting maximum use of the facility and contributing to improved response to system I/O requests.

An optional feature, the *two-channel switch*, permits two channels (of one system or of two separate ones) to have access to the 2305 facility.

2311 Disk Storage Drive Model 1

The IBM 2311 Disk Storage Drive (Figure 7-4) provides direct access storage for 7.25 million bytes (or 14.5 million packed decimal digits and signs) in a single disk pack. Eight disk storage drives can be attached to each IBM 2841 Storage Control, for a total on-line capacity of 58 million bytes per 2841. In addition, unlimited storage capacity is possible because the IBM 1316 Disk Pack in each drive can be easily removed and replaced with another (Figure 7-5).

Each disk pack has six 14-inch disks, mounted ½ inch apart on a vertical shaft. The inside ten disk surfaces are used for recording data, and the outermost two surfaces are protective plates. When the disk pack is installed in the drive, information is written on or read from the surfaces by magnetic read/write heads, mounted in pairs between each two disks on a movable comb-like access mechanism.

The data rate of the 2311 is 156,000 bytes per second, the average access-motion time is 75 milliseconds, and the average rotational delay is 12.5 milliseconds.

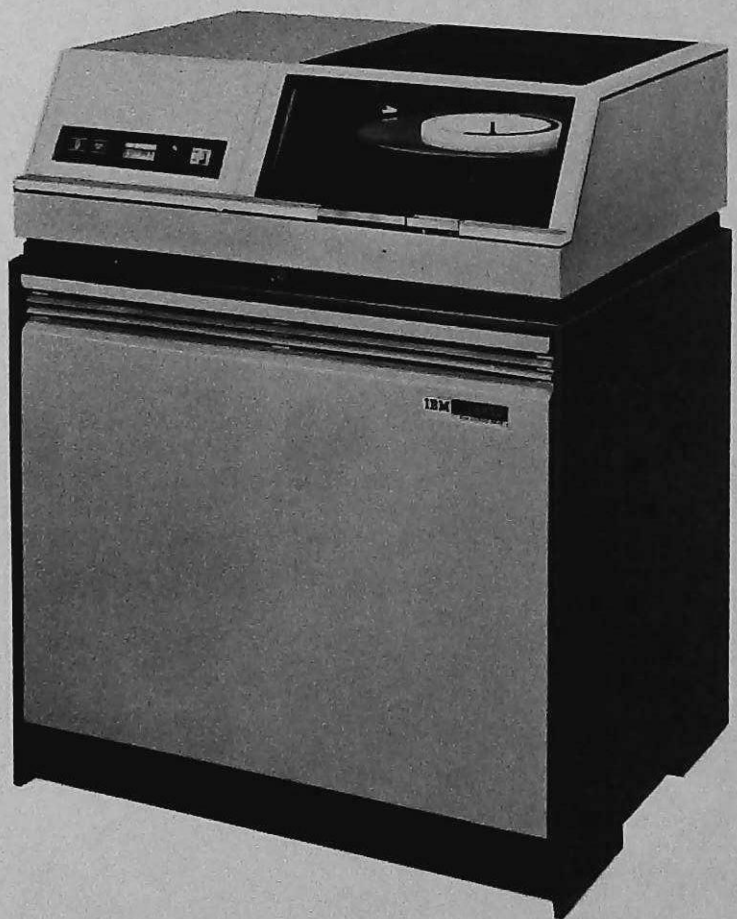


Figure 7-4. IBM 2311 Disk Storage Drive

Figure 7-5. IBM 1316 Disk Pack Being Placed in an IBM 2311 Disk Storage Drive

2314 A-Series Direct Access Storage Facility (2314 Storage Control Model A1 and 2312, 2313, and 2318 Disk Storage Model A1)

2314 B-Series Direct Access Storage Facility (2314 Storage Control Model B1 and 2319 Disk Storage Models B1 and B2)

The IBM 2314 A-Series Direct Access Storage Facility (Figure 7-6) consists of combinations of Model A1 units of IBM 2312, 2313, and 2318 Disk Storage and an IBM 2314 Storage Control Model A1. These devices form an interconnected unit that provides one to nine (eight active, one spare) disk drives. The 2312 provides one drive, the 2313 provides four, and the 2318 provides two.

The B-Series 2314, however, consists of IBM 2319 Disk Storage (one Model B1 and up to two Model B2's) and an IBM 2314 Storage Control Model B1. These devices also form a single interconnected unit, but provide three, six, or nine (eight active, one spare) drives. Each 2319-B1 and -B2 provides three drives.

The drives of a 2314 (both A-Series and B-Series) operate independently and use IBM 2316 Disk Packs (Figure 7-7). Each of these interchangeable packs has a storage capacity of 29.17 million bytes. Consequently, the A-Series can have, in rounded numbers, 29 million to 233 million bytes of online disk storage, in multiples of approximately 29 million bytes; the B-Series can have 87, 175, or 233 million bytes of online storage. Both series can have unlimited offline storage.

For both series, the average access-motion time is 60 milliseconds, the average rotational delay is 12.5 milliseconds, and the data rate is 312,000 bytes per second.

Both the A- and B-Series have the same features. File scan and record overflow are both standard. File scan allows comparison on selected bytes—in effect, a search through the file for a specific record or condition. Record overflow permits more efficient use of storage by allowing a record to overflow from track to track to the end of the cylinder.

A special feature, the two-channel switch, is available to both series. Switching is under program control and may be used to switch the 2314 between two channels of a system or between two systems.

In addition to its own control unit, the A-Series 2314 can have the IBM 2844 Auxiliary Storage Control.

2844 Auxiliary Storage Control

An IBM 2844 Auxiliary Storage Control can be attached to a nine-drive A-Series 2314. When attached, it provides:

1. A second path to the data. With the 2844 on a different channel of the same system, a second path increases throughput by permitting overlapped data transfers on any two drives. Also, the existence of two control units

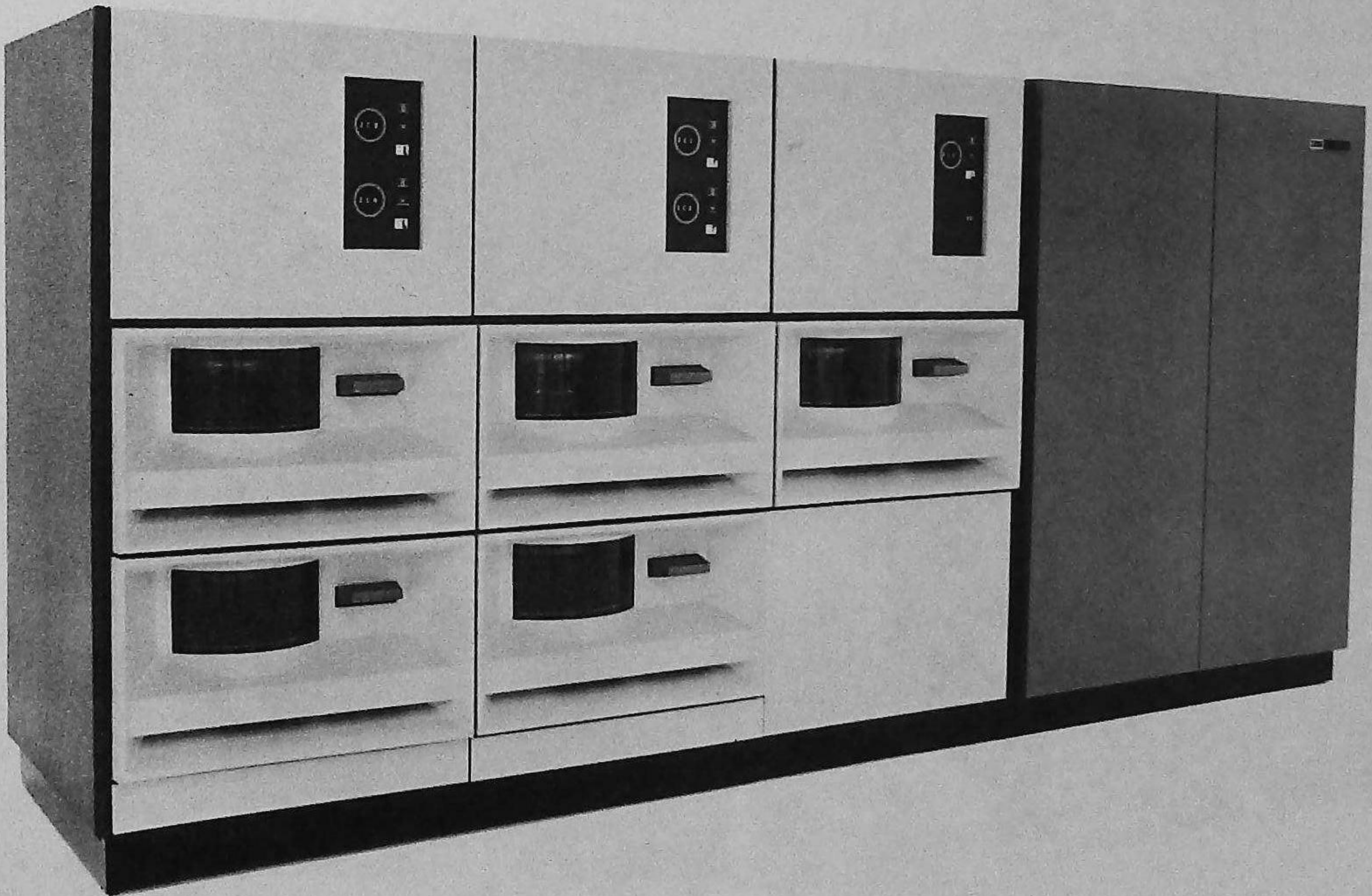


Figure 7-6. IBM 2314 A-Series Direct Access Storage Facility with Five Disk Drives

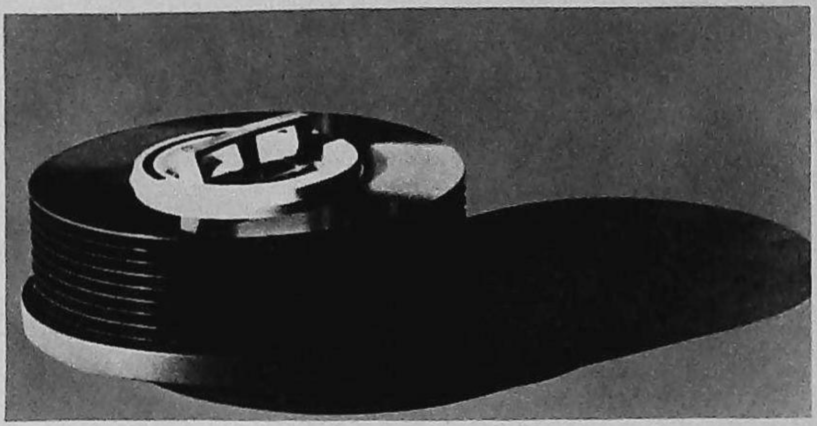


Figure 7-7. IBM 2316 Disk Pack

provides an alternate path to the data, should one storage control need preventive or emergency maintenance.

2. Switching of drive control. Under program control, any of the eight active drives in the A-Series 2314 may be switched between the two control units.

File scan and record overflow are standard features of the 2844. A two-channel switch may be installed on both the A-Series 2314 and the 2844, providing communications between the eight drives of the A-Series 2314 and up to four channels on one or more processing units.

2321 Data Cell Drive

The IBM 2321 Data Cell Drive (Figure 7-8) extends online direct access storage capabilities to a volume of data beyond that of other storage devices. It provides a large storehouse of readily available operating data such as part-by-part inventories, shop schedules, customer accounts of large companies, and manpower records.

Each 2321 offers space for 392 million bytes (or 784 million packed decimal digits with signs) of online data, and has eight million bytes for alternate tracks. Eight 2321's can be attached to a 2841 Storage Control, for a total online capacity of 3.2 billion bytes or 6.4 billion packed decimal digits and signs per 2841 control unit. The data rate is 55,000 bytes per second.

Each data cell drive can contain as many as ten data cells, each having a capacity of 40 million bytes. The data cells are all removable and interchangeable among 2321's, permitting an open ended capacity for data cell libraries.

The storage medium is a strip of magnetic tape 2¼ inches wide by 13 inches long. Each data cell (Figure 7-9) contains 20 subcells of 10 strips each.

Upon activation, a data cell drive rotates its circular array of data cells and positions one of the 200 subcells (20 per cell) beneath an access station. Maximum rotation is 100 subcells because the array always rotates in the direction

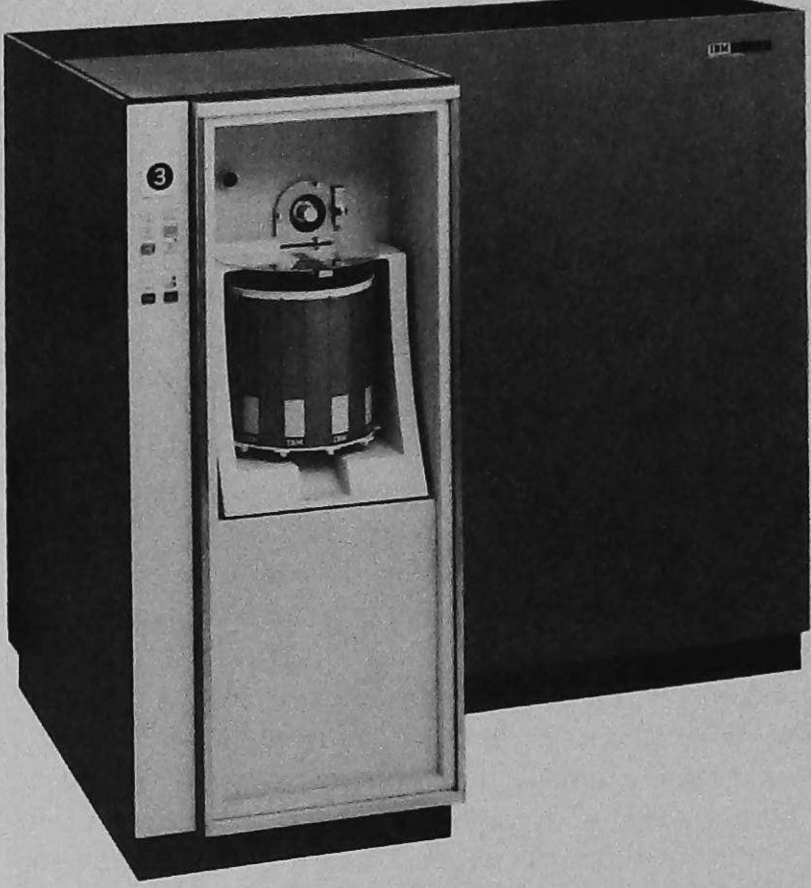


Figure 7-8. IBM 2321 Data Cell Drive

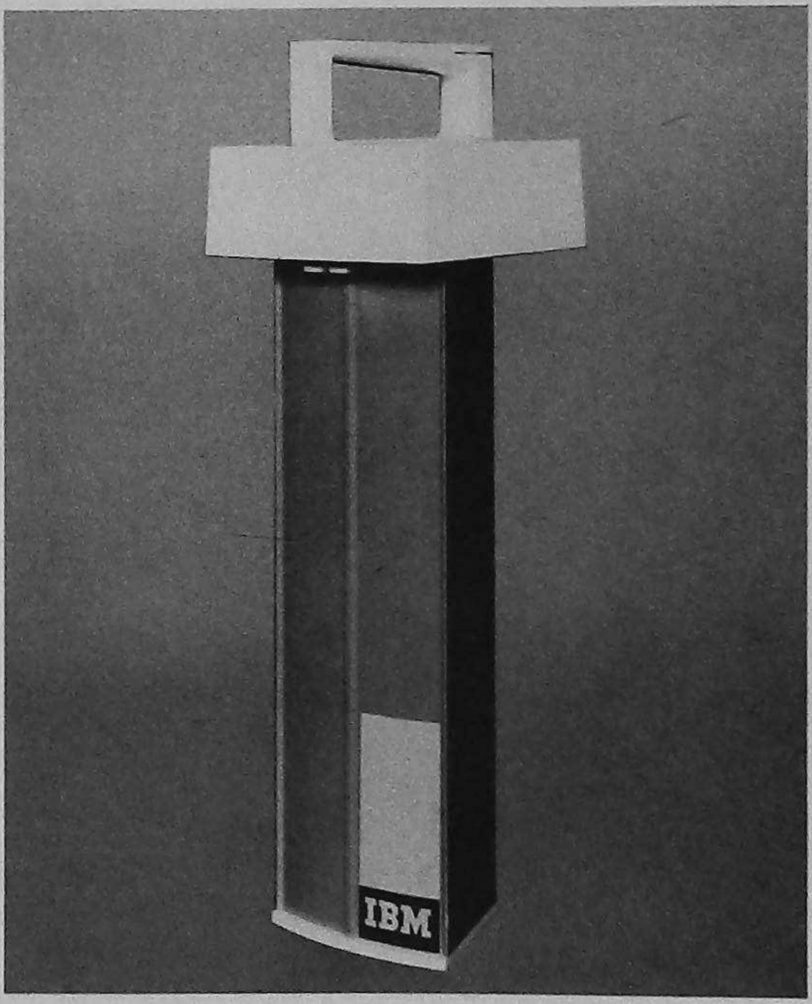


Figure 7-9. IBM 3021 Data Cell (with Top Cover)

that requires less travel. When the addressed subcell is in position, the pickup head selects the addressed strip from among the 10 strips in the subcell. The strip is then placed on a small drum, rotated past a read/write head, and returned to its subcell.

The 100 tracks on each strip are grouped in five cylinders of 20 tracks; the read/write head is composed of 20 elements and can be moved to any one of five positions. In summary, a specific record is addressed by drive (one of 8), data cell (one of 10), subcell (one of 20), strip (one of 10), cylinder (one of 5), and read/write head element (one of 20). Variable-length records of up to 2,000 bytes long can be read and/or written in all available tracks before the strip is returned to its subcell.

Access-motion time to a record varies from 100 microseconds to 650 milliseconds. The minimum time occurs when only switching to another track within the same cylinder is performed. The maximum time occurs when a previous strip must be returned to its subcell, and the array rotated the maximum distance, before the new strip can be withdrawn and the specific record appear (after a complete rotation of the drum) under the read/write head. These and intermediate times (excluding *drum* rotational delay) are given in Figure 7-10. Rotational delay, once a strip is on the drum, is 0 to 50 milliseconds (25 average).

	Time/Number of Subcell Moves			
Conditions	0 Subcell	1 Subcell	50 Subcell	100 Subcell
When only Read/Write element selection is required	100 μs			
When only Read/Write head Block motion is required	95 ms			
When No Strip is on the Drum*	175 ms	250 ms	350 ms	400 ms
When a previously Addressed Strip is on the Drum*	375 ms	450 ms	550 ms	600 ms

* Times given are for access to beginning of track.

Figure 7-10. IBM 2321 Seek Time

2841 Storage Control

An IBM 2841 Storage Control can control as many as eight 2303's, 2311's, and 2321's in different combinations. With no 2303, a 2841 can have as many as eight 2311's and 2321's in any combination; with one 2303, a 2841 can have as many as seven 2311's and 2321's in any combination having no more than three 2311's; and with two 2303's, a 2841 can have as many as six 2321's, but no 2311's.

The 2841 interprets and executes all orders from the system, and checks the validity of the data transferred to and from the "files" (direct access storage devices).

Optional Features

The *two-channel switch* permits switching a 2841 between two channels under program control.

File scan permits searching through direct access storage for a specific record or condition. (This feature is not available for the 2303.)

The *record overflow* feature provides greater utilization of the available storage capacity by allowing a record to "overflow" from track to track to the end of the cylinder (in the 2303, to the end of the drum).

3330 Disk Storage Model 1

3333 Disk Storage and Control Model 1

3830 Storage Control Model 2

IBM 3330 Disk Storage and 3333 Disk Storage and Control (Figure 7-11) provide System/360 with direct access storage that offers modularity, high performance, and large capacity. These qualities make 3330 and 3333 well suited for use in a variety of applications, such as airlines reservations, inventory and manufacturing control, graphic processing, time sharing, message switching, and systems residence.

Up to two 3333's can attach to an IBM 3830 Storage Control Model 2. The 3333's in turn can attach as many as three 3330's, permitting as many as eight drives per 3333.

Each 3330 and 3333 has two disk drives, with an average access-motion time of 30 milliseconds, an average rotational delay of 8.4 milliseconds, and a data rate of 806,000 bytes per second. Each uses IBM 3336 Disk Packs, which are removable and interchangeable units having a storage capacity of 100 million bytes per pack. Because the disk packs are removable and interchangeable, they permit unlimited offline storage capacity.

The storage controls provide functions such as:

Rotational Position Sensing, which increases channel availability by releasing the channel during most of record search time.

Multiple Requesting, which permits up to eight channel command sequences (one per disk drive) to be active in the storage facility, thereby permitting maximum use of the facility and contributing to improved response to system I/O requests.

Command Retry, which enhances error recovery by permitting the channel and control unit to retry operations without CPU program intervention.

Extensive Error Detection and Correction Capabilities, which enhance data integrity and reliability.

Figure 7-11. IBM 3330 Disk Storage and IBM 3333 Disk Storage and Control

The *two-channel switch,* an optional feature, enables a 3830-2 to attach to two channels and (with appropriate programming or operator action) allows individual drives to be reserved for the exclusive use of either one of the channels.

The *two-channel switch, additional,* a 3830-2 optional feature used with the first two-channel switch, doubles the 3830-2's channel-switching ability.

Single-Disk Storage Drive

The single-disk storage drive, a standard part of the CPU for Model 44, provides direct access storage for 1,171,200 bytes on a single disk that is permanently enclosed in an IBM 2315 Disk Cartridge, with side access to the CPU for replacement of cartridges. (All cartridges are available separately.)

The data rate of the disk storage is 90,000 bytes per second. Average access-motion time is 70 milliseconds; average rotational delay is 20 milliseconds.

The disk is organized in 200 cylinders; a cylinder consists of a pair of tracks, one track per disk surface. Each cylinder contains 16 sectors, eight per track and surface. Each sector has a length of 366 bytes; the formal record length is 2,928 bytes (eight sectors).

No programming compatibility exists between the single-disk storage drive and disk storage drives controlled through the 2841 Storage Control.

The drive is attached to the channel via an adapter, also installed in the CPU as a standard feature. A second drive may be installed in the CPU, as a special feature, to double capacity. Both drives operate on one shared subchannel requiring one control-unit position on the channel.

The characteristics of the various direct access storage devices are compared in Figure 7-11.1.

Direct-Access Device	Data Rate (Kilobytes/Sec)	Capacity Available per Device (Megabytes)	Capacity Available per Control Unit (Megabytes)	Access-Motion Time, Average (Milliseconds)	Rotational Delay, Average (Milliseconds)	Storage Medium
2301 Drum Storage	1,200	4.09	16.36	0	8.6	Drum
2303 Drum Storage	303.8	3.91	7.82	0	8.6	Drum
2305-1 Fixed Head Storage	3,000	5.4	10.8	0	2.5	Disk
2305-2 Fixed Head Storage	1,500	11.2	22.4	0	5.0	Disk
2311 Disk Storage Drive	156	7.25 ⓐ	58	75	12.5	1316 Disk Pack
2314 A-Series DASF	312	233.4 ⓑ ⓐ	233.4 ⓑ	60	12.5	2316 Disk Pack
2314 B-Series DASF	312	87.5/175/233.4	87.5/175/233.4	60	12.5	2316 Disk Pack
2321 Data Cell Drive	55	392	3,200	550 ⓓ	25	3021 Data Cell
3330 and 3333 Disk Storage	806	200 ⓒ	800 ⓒ	30	8.4	3336 Disk Pack
S/360 Mod 44 Disk Drive	90	1.17	3.34 ⓐ	70	20	2315 Disk Cartridge

Notes:

ⓐ Interchangeable storage media also provide unlimited offline capacity.

ⓑ In 29.17-megabyte increments.

ⓒ In 200-megabyte increments.

ⓓ Depends on the kind of access; see Figure 7-10.

Figure 7-11.1 Comparison of Characteristics of Direct Access Storage Devices

Display Devices

The IBM 2250 Display Unit (Figures 7-12 and 7-13) provides high-speed visual communication between the System/360 and its user. Tables, graphs, charts and alphameric data are displayed within the 12-inch square central area on the face of a 21-inch cathode ray tube. Keyboards and a light pen supply the means for entry and change of computer information.

The IBM 2260 Display Station (Figure 7-16) is a lower-speed, table-top device for displaying computer output in alphameric form, either locally, or at installations up to thousands of miles distant from the CPU. Data such as insurance records or airline reservations is presented on a 4- by 9-inch area on the cathode ray tube. With the attachment of a keyboard, messages can be keyed in at any location, displayed, and sent to main storage.

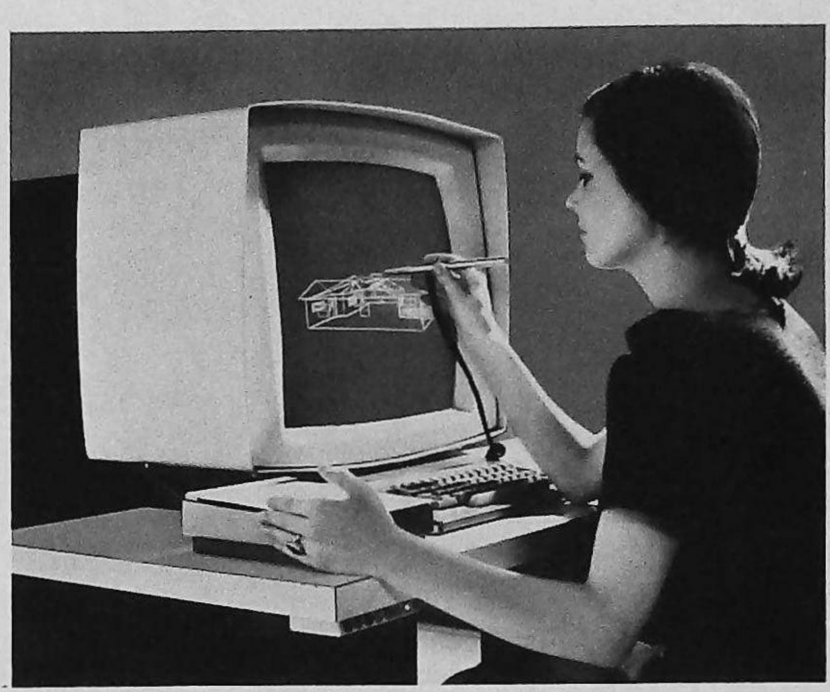


Figure 7-13. IBM 2250 Display Unit with Light Pen in Use

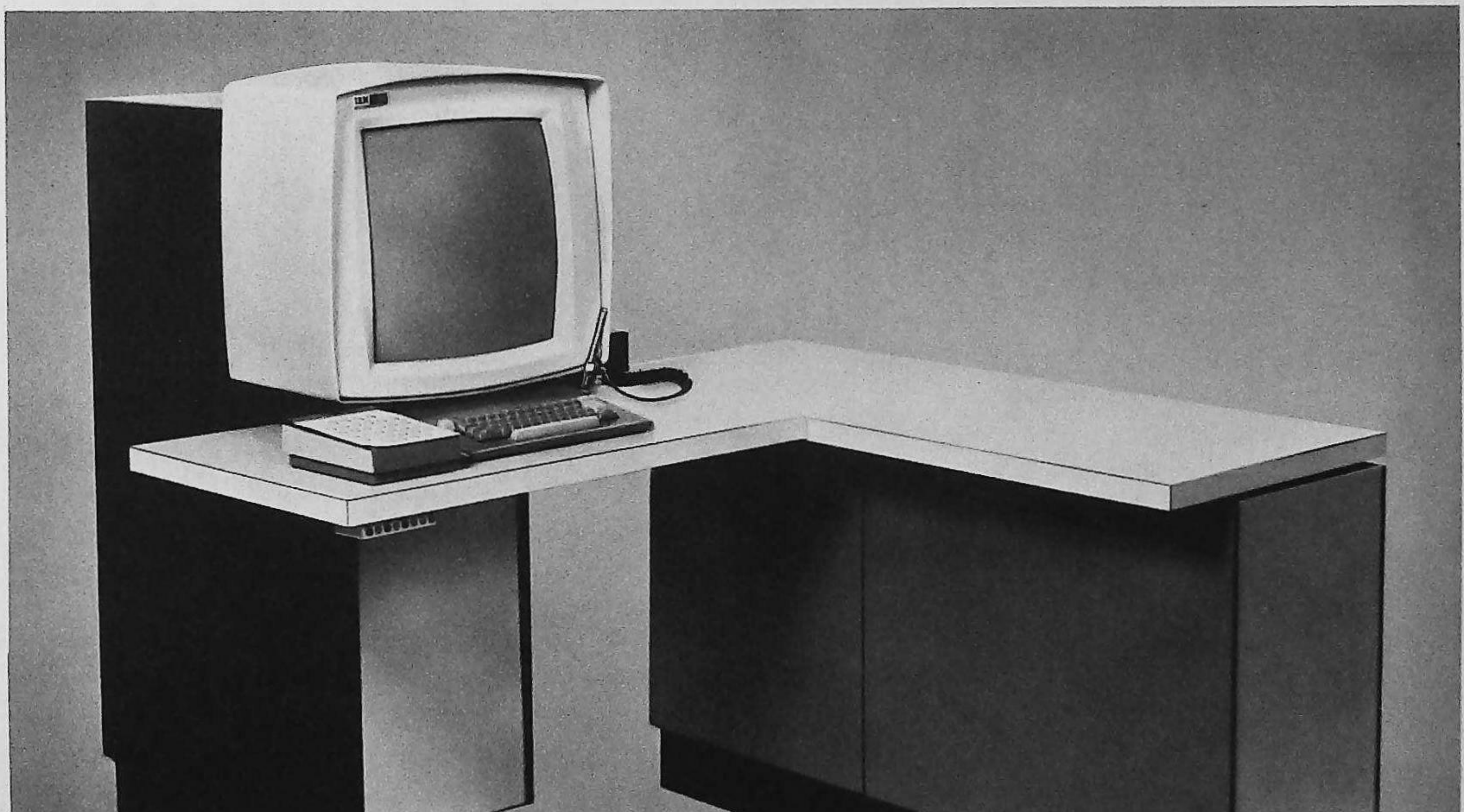


Figure 7-12. IBM 2250 Display Unit

2250 Display Unit Models 1 and 3; 2840 Display Control Model 2

The general use of the IBM 2250 Display Unit is for on-line displaying, updating, and manipulating of drawings and alphameric data. It also has usage as a system operator console, in which it substantially reduces the time needed for transferring messages between the operator and the system.

Specific applications are innumerable: the display of readings from process control indicators, along with computer messages for operator guidance of the process; the display of engineering drawings, with the user sketching changes on the drawings and requesting the results of the changes; or the display of intermediate and/or final results of scientific calculations, in the form of curves, plotted points, bar graphs, or symbols.

The display area (Figure 7-14) contains over 1,000,000 display points that can be individually addressed by X and Y coordinates. The CRT beam is deflected to each point on the screen that is addressed by the program, intensifying that point only if so directed by the program. If the beam motion is only horizontal, vertical, or at 45 degrees, the path traversed by the beam on its way between one end point and the other can also be intensified; by this means, continuous horizontal and vertical lines of unlimited length or 45 degree lines of limited length are made visible. Lines can be displayed at any other angle as a series of dots. A further ability to display continuous straight lines of unlimited length at any angle is detailed under "Absolute Vectors and Control," discussed later in this device description.

The 2250 is available in two models, which vary in the location of the control unit, logical power in the buffer, and in the features that are standard. Model 1 has a self-contained control unit; Model 3 units are linked to the channel and CPU through an IBM 2840 Display Control Model 2.

Multiple Display

A 2840-2 can control as many as four Model 3 display units, each able to operate as far as 2,000 feet away from the 2840. The first two display units are attachable to a standard 2840; for the second two, a display multiplexer feature must be installed on the 2840. As many as eight control units can be attached to a channel.

Different images or the same image can be displayed on all display units simultaneously. The buffer storage in the 2840 is shared by all the 2250's attached, with portions being assigned to individual units by the program.

Light pen tracking can be performed simultaneously by the operator of each 2250 Model 3 without interference to the system.

Special Features

Light Pen (Figure 7-15), a standard feature for the Model 3, is a pen-like device that enables the operator to identify to the program a particular point, line, or character in the displayed image. The operator moves the pen point to the part of the image he wants to identify; the photo-detector associated with the pen, sensing light at that point, generates a signal for the program. The light pen can be used alone or in conjunction with a keyboard to rearrange or delete information, or to add lines from a base point already lighted by the CRT beam.

An "electronic" light pen can be provided alone for the Model 1. Alternatively, a "fiber optics" light pen is provided with the graphic design feature for the Model 1; it is a standard feature of the Model 3.

Programmed Function Keyboard is a 32-key general-purpose keyboard, the keys of which are basically unidentified; with their functions defined by application-oriented interpretation programs. Each key starts a subroutine associated with a particular program. For example, the subroutine might direct the CPU to enlarge, reduce, or delete the image displayed.

Alphameric Keyboard is a typewriter keyboard that permits the user to enter messages consisting of letters, numbers, and other symbols into computer storage. As the message is composed, it is displayed on the screen for verification or editing before it is transferred to main storage. This keyboard also controls the screen location of a movable dash symbol (cursor) that glows beneath the position at which the next character from the keyboard will be displayed.

Buffer (Standard Feature for Model 3) provides the Model 1 display unit with a choice of 4,096 or 8,192 bytes of internal storage. The 2840-2 provides, as a standard feature, 32,768 bytes of storage that are program-assignable to the attached Model 3 display units.

To maintain a display of information on the screen without a noticeable flicker, the display must be regenerated about 40 times per second (the maximum rate actually used). For an unbuffered display, regeneration would have to be performed by the computer. To free main storage and the channel for other functions and to allow the display unit to operate concurrently with the computer, the buffer is used to regenerate the display; the data that defines the image are transferred from main storage to the buffer only once. Also, the buffer is used for the assembling and editing of messages before they are transferred to main storage.

Transfers between main storage and buffer are at the rate of 4.2 microseconds per byte for Model 1, and at an effective rate of 2 microseconds per byte for the

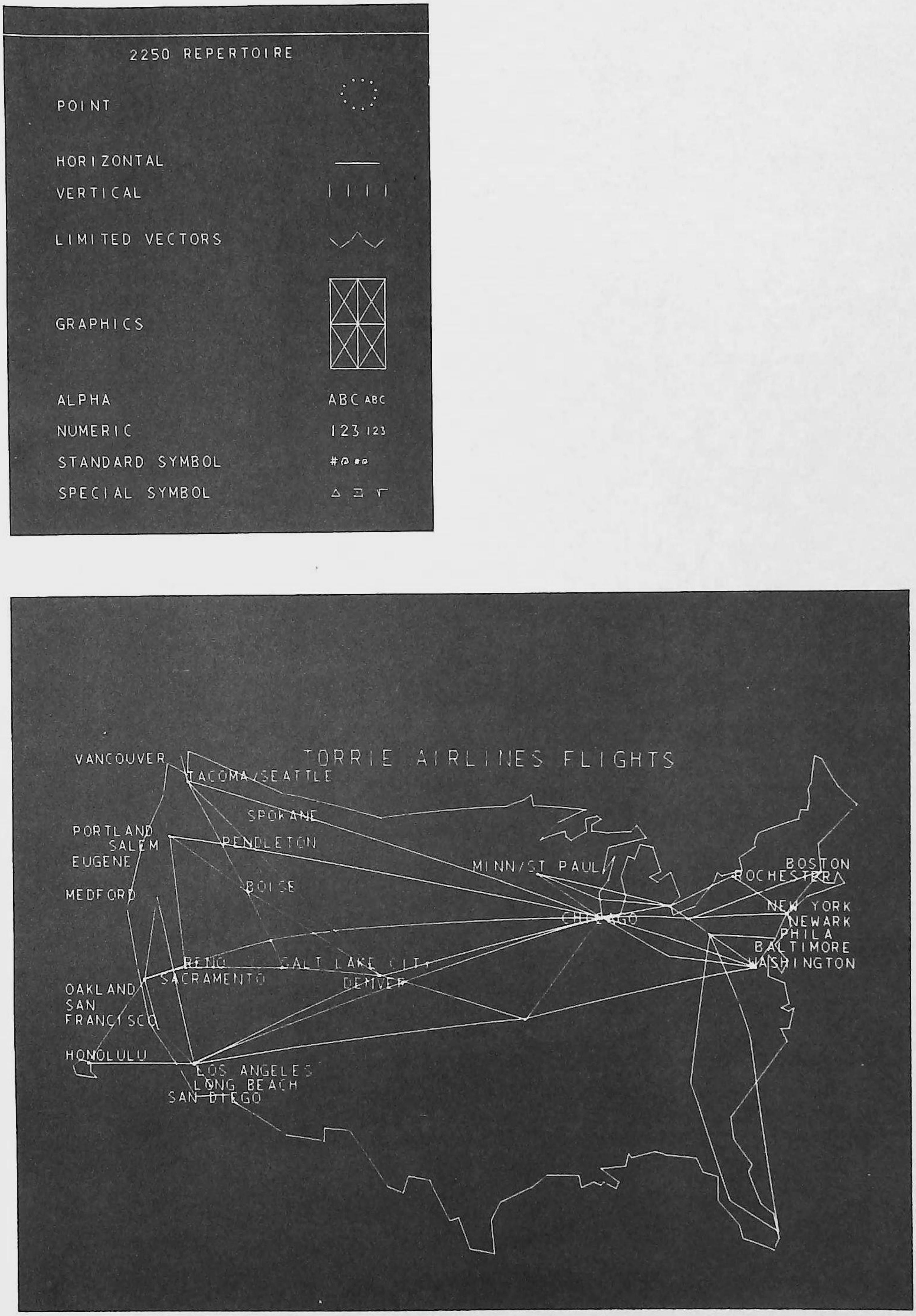


Figure 7-14. IBM 2250 Displays Showing Absolute Vector Graphics, Point Plotting, and Both Sizes of Alpha Characters

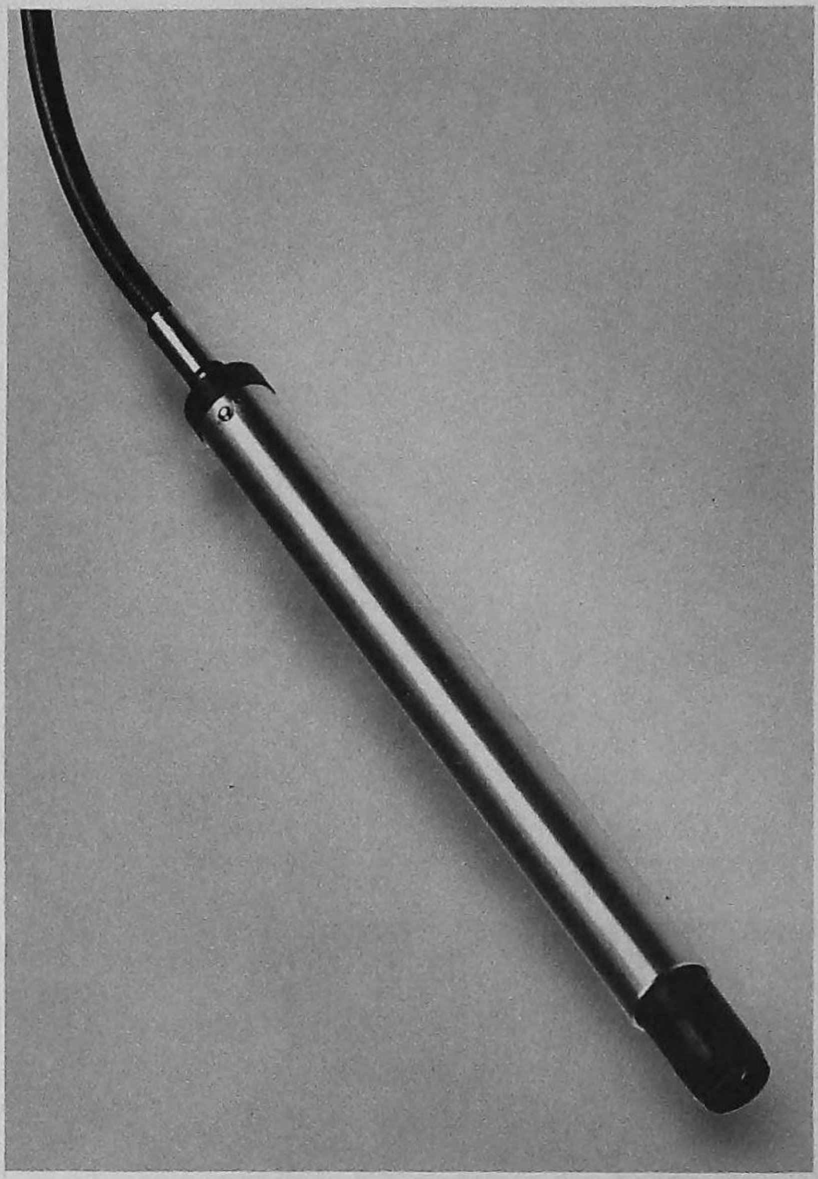


Figure 7-15. Fiber Optics Light Pen

2840 used with Model 3's. Thus, the buffer can accept data from the CPU at the rate of 238,000 bytes per second for Model 1, or 500,000 bytes per second for the 2840. (The 32K buffer in the 2840 can be completely rewritten in less than a tenth of a second.) In communication between the 2840 and Model 3's, the buffer is accessed at only 1 microsecond per byte. Points can be displayed as fast as 16.8 microseconds per point.

Character Generator (Standard Feature for Model 3) translates a byte specifying an alphameric character into the analog signals necessary to trace the character on the face of the tube; relieves the program of the task of individually addressing a series of dots or lines that are synthesized on the display into the specified character. Instead, a single data byte from the CPU specifies one of the characters available with the charactor generator. Two character sizes are program selectable: basic size or 1½ times basic size. The screen has room for 3,848 basic-size characters (on 52 lines of 74 characters each) or 1,715 1½-size characters (on 35 lines of 49 characters each). The latter case is equivalent to about two thirds of a column on this page. The average time required to display alphameric data with this feature is 15 microseconds per character for the basic size or 17 microseconds for the 1½ size. The number of characters per second depends on the program. Characters can be displayed from the buffer at the rate of 60,000 per second.

Operator Control Panel (For Model 1 Only) duplicates the facilities in the operator control section of the system control panel on the processing units of System/360 Models 50-91. One or two operator control panels can be installed on the 2250 Model 1. Two panels enable the 2250 to control either of two systems (Models 50-91) in a multisystem.

Absolute Vectors and Control (Standard Feature for Model 3) enables the 2250 Model 1 to trace continuous straight lines at any angular position within the 12-inch by 12-inch display area on the CRT. A line (vector) can be drawn between any two addressable points. More than a million points are addressable: 1,024 on the X axis by 1,024 on the Y axis, XY coordinates are programmed to specify the point to which each vector is drawn.

Graphic Design (Standard Feature for Model 3) provides (1) incremental vectors and point plotting, (2) a special fiber optics light pen, (3) light pen control orders. For the Model 1, the absolute vectors and control feature is a prerequisite.

In the fiber optics light pen (Figure 7-15), light is transmitted from the screen back to a sensing device in the console through a flexible connection made of glass fibers. Also, instead of being used in conjunction with a foot switch, this new light pen has a tip switch that is operated by depressing the pen tip on the screen.

Through programming, the graphic design feature enables the user to locate the light pen on a blank part of the screen, or to track the pen's path, with a minimum of CPU interruption. Locating the pen (pen search) is done by momentarily sweeping the screen with characters or short vectors and saving the XY location of the one character or vector that activated the light pen. Pen search is a good way to initiate pen tracking.

In pen tracking, a small cross or box is displayed under the pen and moves with the pen; the cross or box supplies the light to keep the pen activated, and the program updates the symbol location. In one tracking technique, a light trail can be made to follow the pen much as an ink trail follows an ordinary pen. Alternatively, a single vector can be displayed from each starting point of tracking to the pen, for an effect called rubber banding. The incremental vectors and light pen control orders provided by the graphic design feature enable pen tracking to be directed by the CPU and buffer programs. (With the 2250 Model 3, only the buffer program is needed.) With the user's program as aided by this feature, there is no need for the CPU to compute every point on the tracking symbol as it is continually relocated, because resetting the starting point of the first vector moves the entire symbol to the new location.

With the incremental vectors, a line is drawn to any point on the screen, up to 0.74 inch from the absolute X and Y values of the starting point, by specification of increments along the X and Y axes rather than by absolute specification of the destination point. The same distances and method of specification apply to incremental point plotting. With a series of changes in the starting point and by use of an appropriate subroutine within the buffer, an image such as a resistor or a rivet head can be made to appear at many places on the screen simultaneously.

Features of 2840 Model 2

The only special feature for the 2840 control is the display multiplexer, which permits the attachment of two additional 2250 Model 3's for a total of four. No more than one display multiplexer can be installed per 2840 Model 2.

Many functions can be performed totally within the standard 32K-byte buffer, thereby eliminating many interruptions and programming task-switching operations in the CPU.

Other standard features of the 2840-2 are the character generator, absolute vectors, incremental vectors, and light pen control orders that are provided with special features for the Model 1 display unit. The subroutine capability within the buffer permits the displaying of an image such as a resistor at many places on the screen even though the control orders appear only once in the buffer program.

Unique Equipment

The System/360 Model 91 has a display console that is, essentially, a 2250 Model 1 equipped with:

One operator control panel
Alphameric keyboard
Character generator
4,096-byte buffer

The display console is a standard feature integrated with the system control panel. When switched to a maintenance function, communication is from the system control panel to the display console; when switched to the channel (normal connection), the display console is used for two-way communication with the CPU.

The following may be added to the display console as special features:

Light pen
Absolute vectors and control
Programmed function keyboard
Second operator control panel
Graphic design

The existence of this display console for the Model 91 does not preclude the attachment of 2250's in the conventional manner.

On the Model 67, either the 2250 Model 1 or the 2840 may be switched between two channels.

• 2260 Display Station Models 1 and 2; 2848 Display Control Models 1, 2, 3, 21, and 22

The IBM 2260 Display Station (Figure 7-16), operating through an IBM 2848 Display Control, is an efficient and compact visual-display terminal. It provides immediate visual access to local or remote System/360 storage for data entry, retrieval, and revision.

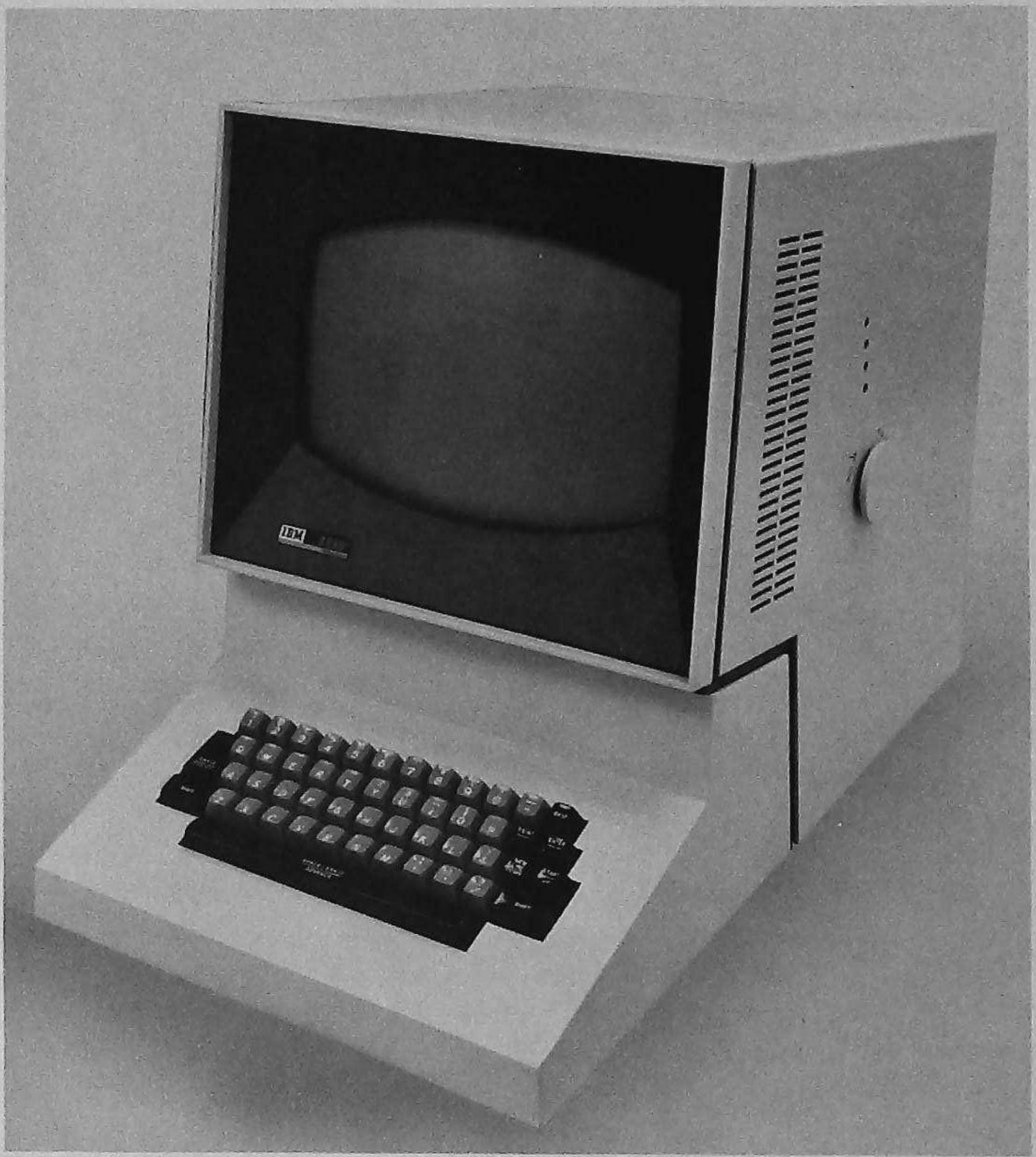
Using the 2260, a user can store, retrieve, and display alphameric data conveniently and quickly. Via the 2260 keyboard, he can query the system for information about an account, a transaction, a production schedule, etc. The inquiry is quickly processed and the desired information is displayed on the 2260 cathode-ray-tube screen and retained there for as long as desired. The user can revise the information via the keyboard and return it to the computer for storage or additional processing. If the keyboard-equipped 2260 also has a printer feature, displayed information can be directed to a 1053 Printer, where it is printed in the same format as displayed on the 2260 screen. The basic 2260 (without a keyboard) is used when only the display of information is required.

Flexibility of Display Configuration

The 2260/2848 display configuration can vary from one display-only 2260 with one 2848 to a multiple-station complex consisting of many 2260's and 2848's in which each station can be used as a data-entry terminal. Because each 2260 can be operated independently, many unrelated display operations can be performed concurrently with no interaction between display stations.

A 2260 Display Station can operate within 2000 cable-feet of its associated 2848. Display stations can be located strategically throughout an office building, manufacturing plant or similar facility, thus providing access to computer data at locations removed from the computer area.

When attached to the appropriate teleprocessing facilities, a 2260 can communicate with a computer located many miles away as easily as if both were in the same room.



• Figure 7-16. IBM 2260 Display Station with an Alphameric Keyboard

Ease of Operation

After learning the functions of the special keys and characters, entering data via the keyboard is as simple as typing. The operator keys in the desired information and visually verifies it as it appears on the screen. If an error is made, the operator can backspace and correct it. The information can then be transferred to the computer by pressing another key.

Inquiries are addressed to the computer in the same way; the computer's response is displayed on the screen for action by the operator. The displayed data is updated, corrected, or deleted via the 2260 keyboard. The format of the data to be handled by the display station can be programmed beforehand to avoid entering repetitive information.

Model Differences

The basic differences between 2260 Models 1 and 2 are in the amount of data capable of being displayed within the 4-by-9-inch display area, determined by the 2848 model and the special features that permit expansion of the configuration.

The models of the 2848 differ in the service that they support. The 2848 Models 1, 2, and 3 are used primarily in inquiry-oriented configurations; Models 21 and 22 combine the advantages of the other models with increased data input capabilities.

2848 MODEL	2260 MODEL	MAX NO. OF 2260's PER 2848		DISPLAY CAPACITY (CHARACTERS)
		WITHOUT EXPANSION	WITH EXPANSION	
1	2	4	24	240 (6 lines, 40 char/line)
2	2	2	16	480 (12 lines, 40 char/line)
3	1	2	8	960 (12 lines, 80 char/line)
21*	2	12	24	240 (6 lines, 40 char/line)
22*	2	8	16	480 (12 lines, 40 char/line)

*Models 21 and 22 of the 2848 cannot be used for remote (teleprocessing) installations.

The 2848 contains a buffer that can hold up to 240, 480, or 960 bytes per display, depending on the model. It also contains the character generator that converts data from the channel or signals from the keyboard into the visual display.

All 2260's are attached to 2848's through display adapters, with each adapter providing control for two 2260's. Additional display adapters can be attached to a 2848 by adding expansion features to it, thereby extending the capability of the 2260/2848 display configuration, as shown in the preceding table.

Keyboards

Three different keyboards are available for the 2260: the alphameric, the numeric, and the alphameric with numeric inset. The alphameric keyboard is organized similar to a typewriter keyboard. The numeric is arranged the same as a ten-key adding-machine. On the alphameric with numeric inset, the numeric keys are inset in the keyboard in a block arrangement for rapid numeric data entry. All three have special symbol keys and control keys required to enter data.

The keyboard determines the characters and symbols that can be key-entered on a 2260, but does not determine which ones can be transmitted from System/360 storage (either main or auxiliary) for display on a 2260 screen. For example, a 2260 can display alphameric data even if it has only a numeric keyboard.

Printout on 1053 Printer Model 4

The contents of the 2848's buffer storage, or information from the channel, can be printed out on an IBM 1053 Printer Model 4 attached to the 2848. One printer can be attached to each 2848 in the system. The attachment requires a 1053 adapter in the 2848; when the 2848 is a Model 1 or 2, an expansion feature is also required. The buffer for a 1053 has a capacity of 1,223 bytes.

The 1053 is further described under "Printers."

2285 Display Copier

The IBM 2285 Display Copier (Figure 7-17) is a non-programmed attachment to the IBM 2250 Display Unit Models 1 and 3; it provides an 8½-by-11-inch paper copy of the information displayed on the 2250. The 2285 enables the 2250 user to record displayed information in a form that can be readily seen, used, and filed for future reference. To obtain a copy of the information displayed on the 2250, press the copy pushbutton on the 2285, which initiates a copy cycle. Analog signals are then switched from the 2250 to the 2285, where they drive a smaller cathode-ray tube (CRT). The image from the CRT is enlarged and projected onto dry-silver photographic paper. Once the paper is exposed, the analog signals are switched back to the 2250, which is again available for use. Completion of exposure also activates the paper transport mechanism, which advances the paper and cuts it to an 11-inch sheet. This exposed sheet is then developed by a heat roller (dry process), producing a black image on a light gray background. A five-position switch allows the operator to vary image density as desired. Both the setting of this switch and the vector and character content of the 2250 image govern the copy cycle time which, for all flicker-free images, will vary from 15 to 38 seconds (approximately).

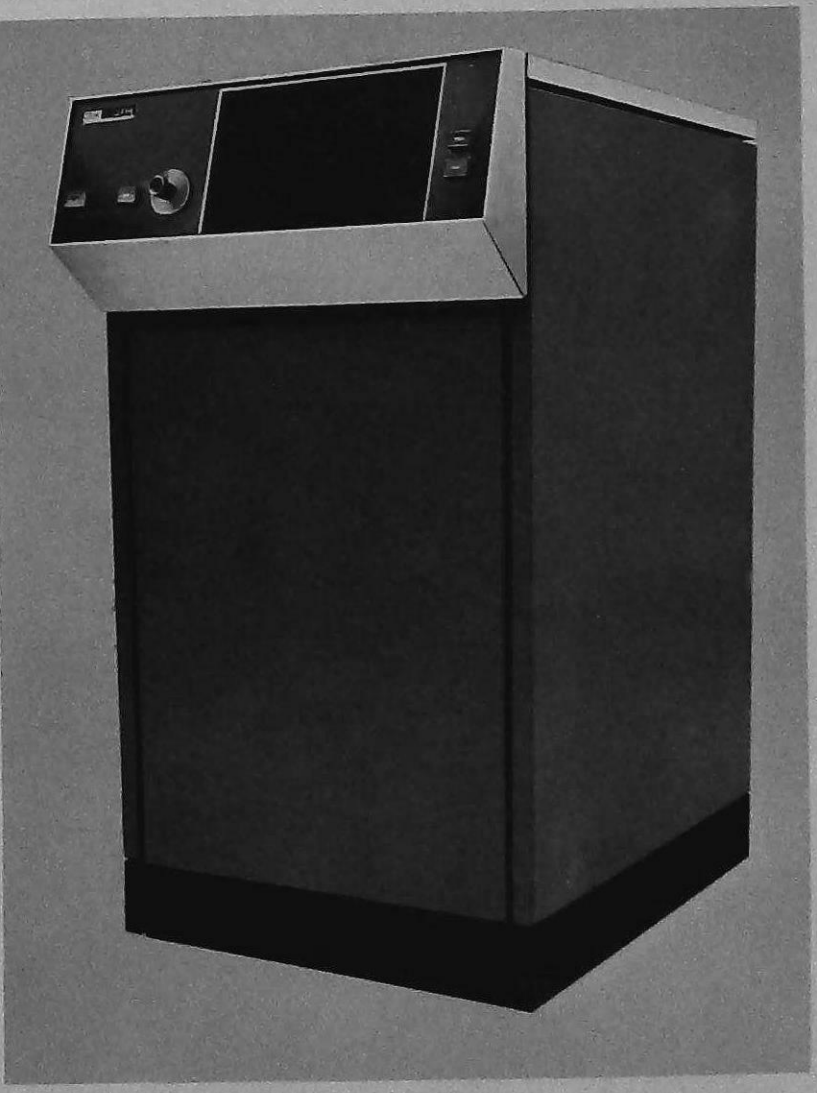


Figure 7-17. IBM 2285 Display Copier

A display copier attachment feature is required on the 2250 to enable attachment of a 2285. Also, the absolute vectors and control feature and a buffer are required on the 2250-1. The 2285 is conveniently located so that its controls, indicators, and hopper are easily accessible to the 2250 operator.

Paper

The copy medium used by the 2285 is dry-silver paper. Dry-silver is a light-sensitive material with a developing agent that is coated on a paper stock. The coated paper is resistant to curl, has sufficient weight for easy handling, and has a feel similar to conventional noncoated paper — characteristics that make it suitable for many reference applications. It has excellent resolution and exposure latitude. Prints are neither moisture- nor pressure-sensitive, and can be written on with pen or pencil; pencil marks are easily erased.

Paper for the 2285 is in roll form supplied in light-tight containers. Each roll contains 500 feet of 8½-inch wide paper, enough paper for about 545 8½-by-11-inch prints.

Image Formation and Development

An image is formed on dry-silver paper in much the same way as on conventional photographic papers. Light projected from the 2285 CRT strikes the paper, causing a permanent latent image. The paper reverses the polarity of the projected image so that the negative appearance of the CRT image (bright image on dark background) becomes a positive image (black image on a light background) on the paper.

The latent image formed on the paper is developed by a brief application of heat. During this time, the developing agent and the exposed light-sensitive material, both coated on paper, react to form a visible image.

Copy

Copy from the dry processor is placed in the hopper, which can hold as many as 20 copies. The time required to obtain a completed paper copy is 12.5 seconds plus exposure time. A new copy cycle can be initiated after the previous exposure has been cut (about 5 seconds after exposure is complete). When the end-of-roll condition is reached, the ready light is turned off and the copy pushbutton deactivated.

A right-reading image on the 2250 results in a right-reading image on paper. The 11-inch side of the copy is vertical, and the image area is approximately centered vertically. Horizontally, the image is off-centered to the right of the paper, providing a ½-inch margin along the left side of the paper for hole punching or binding.

Magnetic Ink Devices

1259 Magnetic Character Reader Model 2

The IBM 1259 Magnetic Character Reader Model 2 (Figure 7-18) provides smaller banks with an economical device for reading magnetically inscribed card and paper documents at speeds up to 600 six-inch documents per minute.

The 1259 can handle intermixed paper and card documents ranging from 2.5 to 4.14 inches wide and 5.5 to 8.75 inches long. Documents less than 3.5 inches in length cause the machine to stop; documents at least 3.5 inches but less than 5.5 inches long are automatically rejected by the 1259 and are not read. When the document width is 4.00 inches or more, the document length must be 7.00 to 8.75 inches.

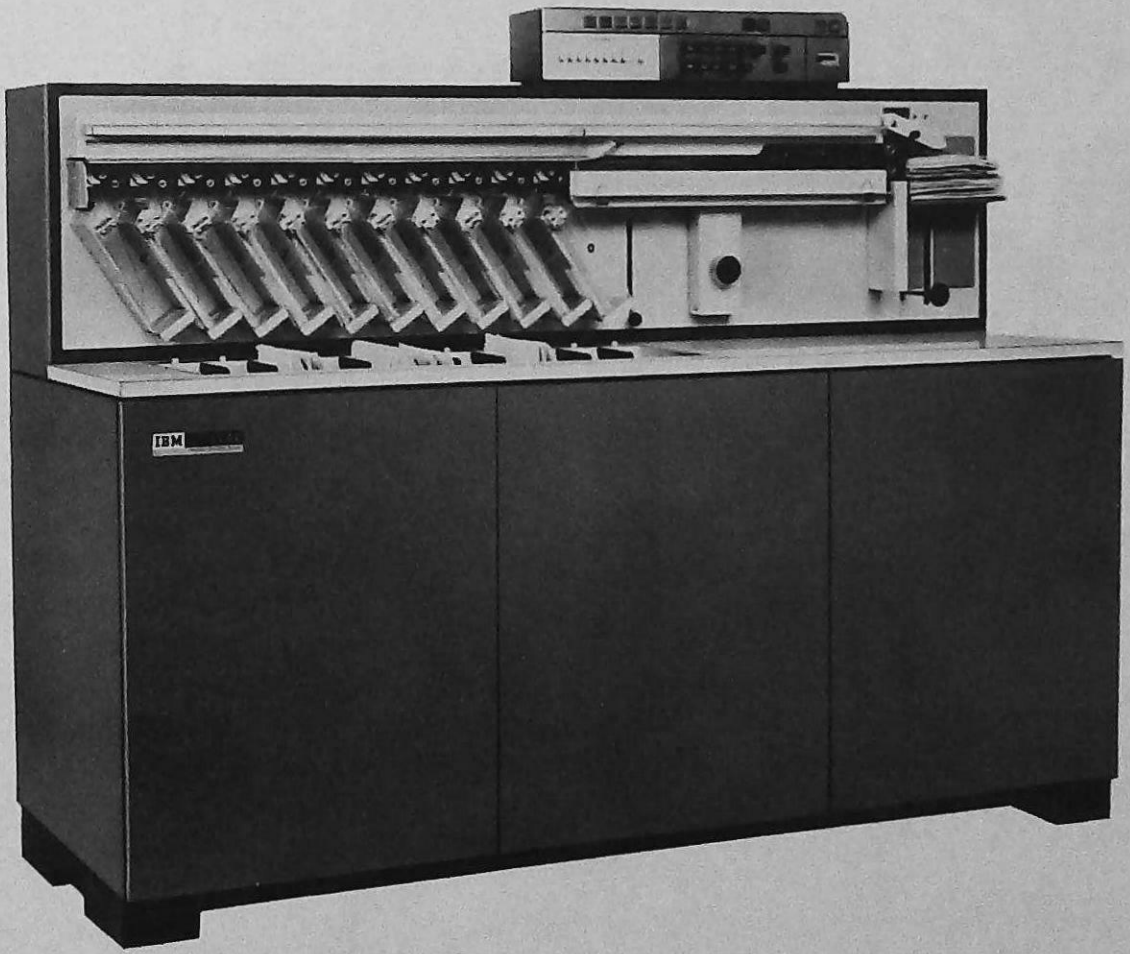
For operations with the 1259, the amount field and the transit-routing field on a check or other document are fixed lengths of ten and eight digits, respectively. The process-control field can vary in length from zero to six digits and the serial-number field from zero to ten digits. The account-number field may be fixed (at five to ten digits) or variable (at one to ten digits), as specified by the customer.

As a document is processed, the validity of each magnetic character, including special symbols, can be verified, and characters found to be invalid are sent as asterisks to the CPU. Additionally, a field-length check is made of all fixed-length fields being processed to ensure that all digits in the fields have been read. Documents must be directed under program control into one of the eleven stackers; otherwise, feeding stops, and the operator must reset the 1259.

Only one 1259 can be attached to a system and requires a control unit position on a channel. Recommended attachment is to the multiplexer channel, with the 1259 normally having the highest priority on that channel.

1412 Magnetic Character Reader; 1419 Magnetic Character Reader

An IBM 1412 or 1419 Magnetic Character Reader can be attached to a System/360 channel for reading magnetically-inscribed data on checks and other banking documents (Figure 7-19). The 1412 and 1419 differ mainly in document-reading rates: the 1412 reads at speeds as high as 950 documents per minute; the 1419, at speeds as high as 1,600 per minute. (The 1419 is



● Figure 7-18. IBM 1259 Magnetic Character Reader

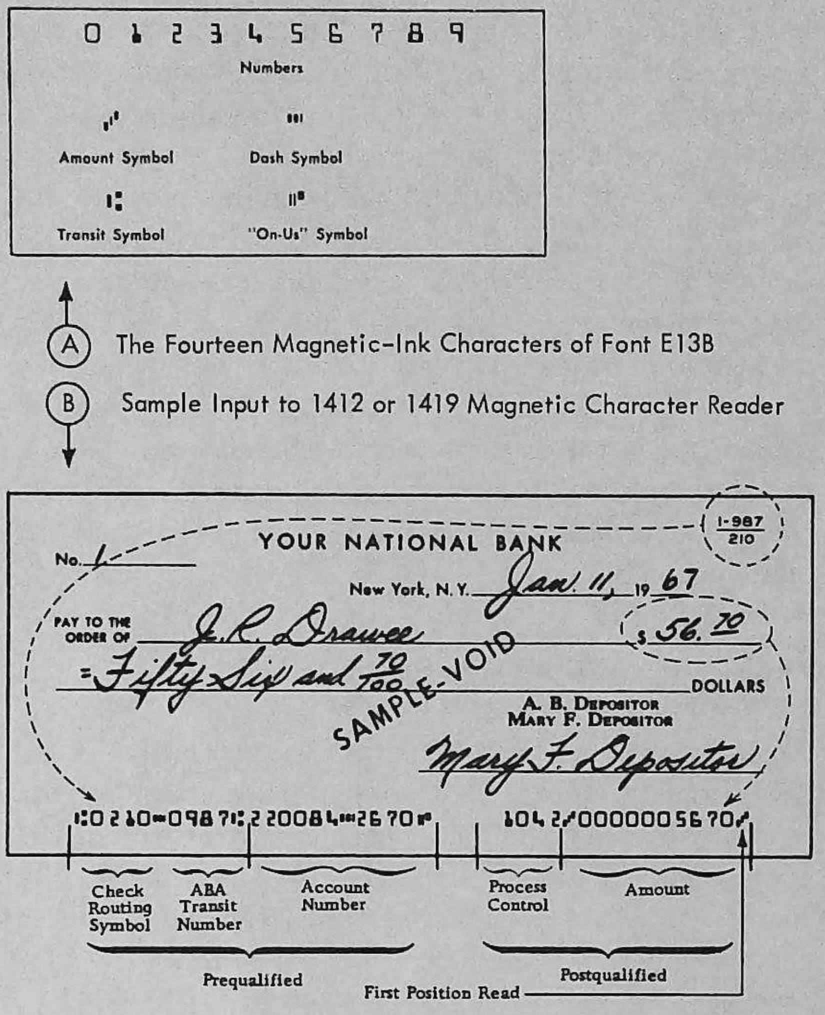


Figure 7-19. Magnetic Inscription – Translation of Characters and Definition of Fields

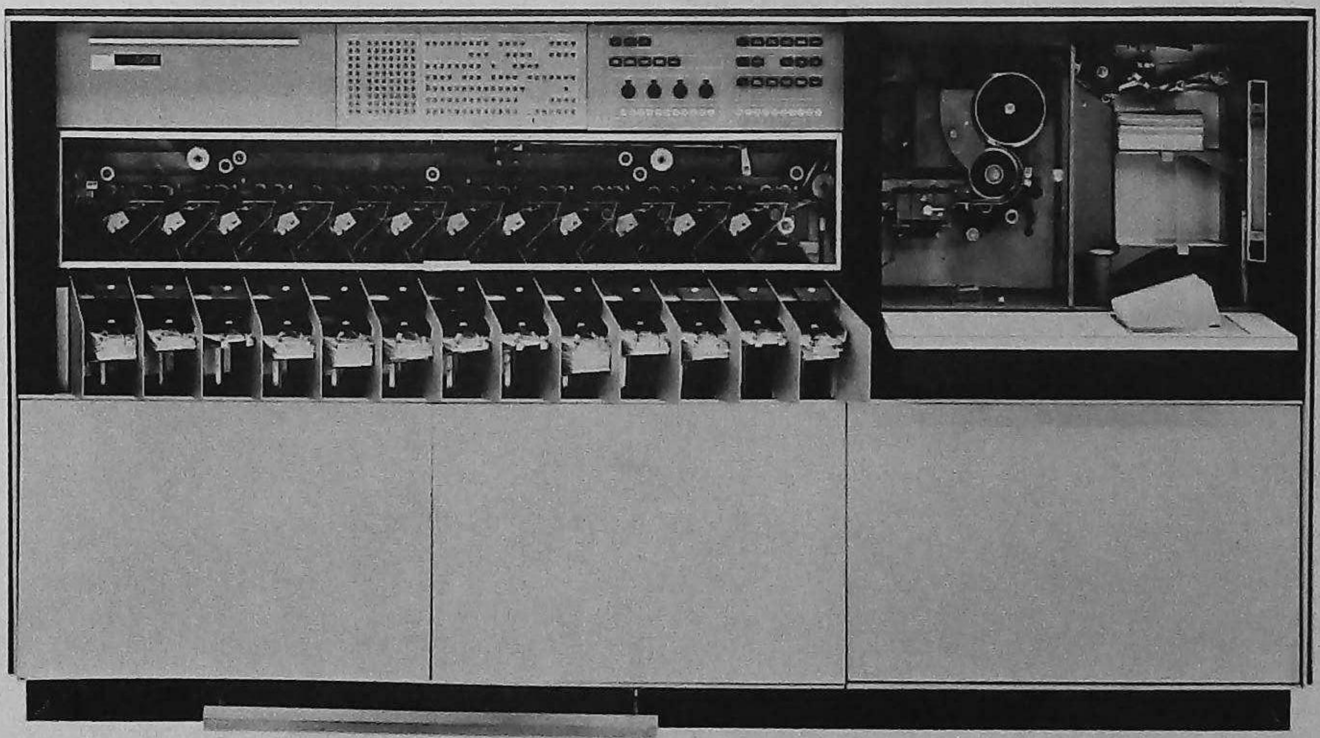
shown in Figure 7-20.) Specific speeds depend on document length as well as on the program.

As the documents are read, they may be sorted into as many as 13 classifications: A, B, 0-9, and R (reject). All magnetic inscriptions can be validity-checked.

Documents read may be of intermixed sizes and thicknesses, as typically encountered in check-handling operations. The standard minimum length is 6 inches; shorter documents, such as the 51-column postal money order, can be read into the system, by the 1419 only, at a maximum rate of 1,960 per minute.

These shorter documents can be intermixed with standard-length documents, and can also be sorted if a no-charge special feature for that purpose is installed. If the feature is not installed on the 1419, 51-column cards and other documents less than 5 inches long are sent to the reject pocket. If the feature is installed, 1419 speed is reduced by an amount that increases slightly with the average length of documents and is 4.3 percent for 51-column cards, and 5.3 percent for 6-inch checks.

Many special features are available for both the 1412 and 1419, including an endorser to print the bank's endorsement on the back of each document at no reduction in operating speed. Other features most applicable to on-line operations with the System/360 are:



● Figure 7-20. IBM 1419 Magnetic Character Reader

READER	FEATURE	PURPOSE
1412, 1419	Dash Symbol Transmission	Distinguish U. S. from Canadian transit-routing numbers (leftmost eight magnetic digits), to prevent duplications.
1419	Batch Numbering	(Self-evident)
1412, 1419	Self-Checking Number	Automatically perform mathematical proof that account numbers are correctly recorded and read.
1419	Program Control for Pocket Lights	Improve control of output batches. Stops the reading-sorting and turns on pocket light(s) when a predetermined number of documents has entered one of the corresponding six pockets (with a second feature, 12 pockets) designated by the program.

One 1412 can be attached to a system. As many as six 1419's (each requiring a control-unit position on a channel, as well as System/360 single or dual address adapter) may be attached to the system.

Magnetic Tape Devices

• 2401 Magnetic Tape Unit Models 1-6

The IBM 2401 Magnetic Tape Unit (Figure 7-21) reads and writes data on half-inch magnetic tape with data densities of 800 or 1,600 bytes per inch (bpi). The 2401 uses IBM Series/500, Dynexcel, or equivalent tape for either data density, and may use MYLAR* tape for 800-bpi operations.

The 2401 Models 1-6 usually record data in a nine-track format; but Models 1-3 can be made to record in a seven-track format. The nine-track format uses eight of the nine bits for data and the last one for parity. The data bits can represent an alphameric or special character, two decimal digits, one signed decimal digit, or eight binary digits. With appropriate features on the tape control, the seven-track format is compatible with tapes written by 700- and 7000-series tape units (727, 729, 7330, 7335, 7701, 7702, and 7765).

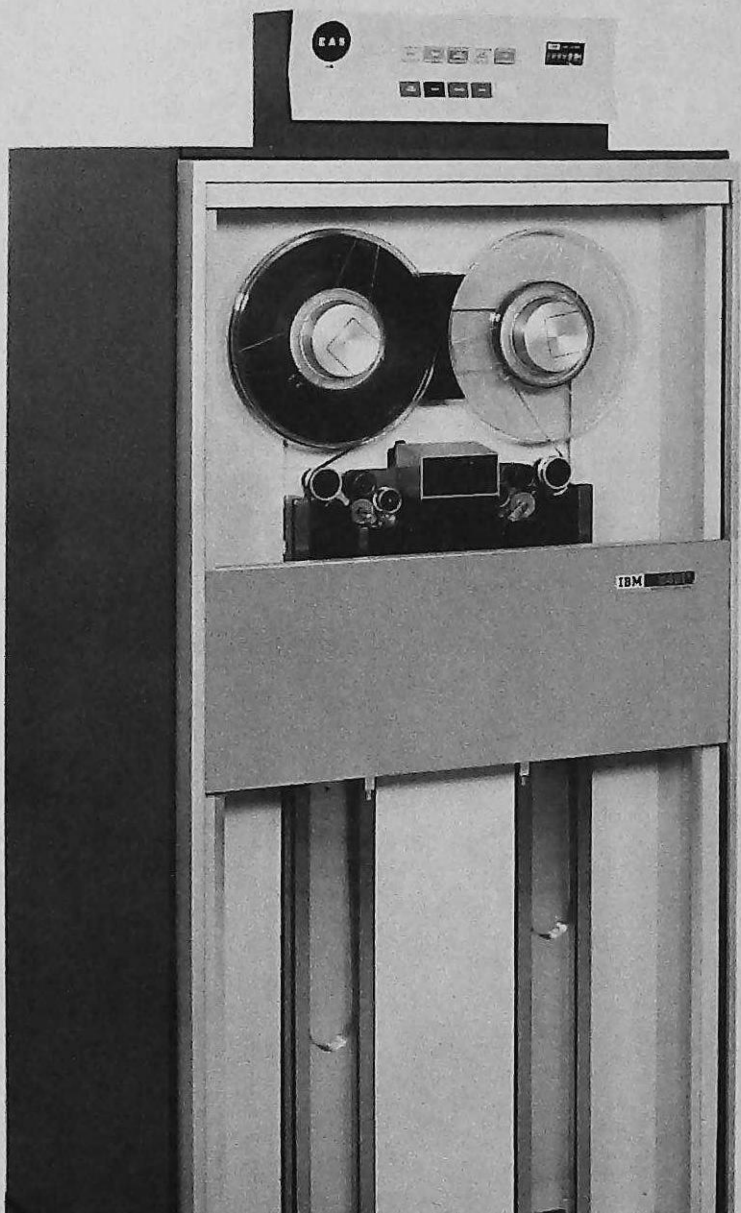


Figure 7-21. IBM 2401 Magnetic Tape Unit Model 2, 3, 5, or 6 (Using Transparent Reels)

The 2401 Models use the non-return-to-zero-IBM (NRZI) method of recording information on tape; Models 4-6 use phase encoding. (In NRZI recording, only 1-bits are recorded; the absence of a 1-bit is interpreted as a 0-bit. In phase encoding, however, both 0-bits and 1-bits are recorded.) Phase encoding has advantages over NRZI in that it increases both reliability and data density and provides "in-flight" (during-reading) correction of single track errors.

Standard Features

Parity Checking: This is done during tape reading (in both 800- and 1,600-bpi recording) and during read-back check of tape writing (in 800-bpi recording, and in 1,600-bpi recording if the control unit is a 2803-2 with 2420 attachment capability).

Amplitude Checking: In 1,600-bpi recording, the amplitude of the signal is checked against a predetermined threshold level. This check determines whether the signal of the data being recorded is strong enough to permit the data to be read.

Error Correction: Single track errors are automatically detected and corrected:

1. In flight, when using the 1,600-bpi nine-track format.
2. During the re-read of a record that contains one or more errors confined to a single track, when using the 800-bpi nine-track format. All other errors are detected, and conventional error recovery routines apply.

Read Backward: Tapes written on any 2400-series tape unit (2401, 2402, 2403, 2404, 2415, or 2420) can be read by any other 2400-series unit either backward or forward, provided the writing and reading units operate with the same tape density and format. However, the data conversion feature of a 2803 or 2804 Tape Control cannot be used when the 2401 is reading seven-track tape backwards.

Power Window: This tape access window (standard on most units) facilitates tape changes by opening automatically following a tape unload and closing automatically prior to a tape load operation. The power window can also be opened or closed at the touch of a button.

Quick-Release Latches: Each tape unit has quick-release latches to facilitate the mounting and removal of tape reels.

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*Trademark of E. I. du Pont de Nemours & Co. (Inc.)

Optional Features

Dual Density 800-1,600 bpi (2401 Models 4-6): This feature allows a program to use a tape unit in either 800- or 1,600-bpi recording. It requires that the 2803 or 2804 Tape Control be equipped with a nine-track or seven-and-nine-track compatibility feature. (See the 2803 and 2804 descriptions for details.)

Simultaneous Read-while-Write: This feature is required on any 2401 attached to a 2804 (a two-channel simultaneous read-while-write tape control).

Mode Compatibility: This feature is required to attach 2401 Models 1-3 to a 2803 or 2804 Model 2.

Further characteristics of the 2401 are shown in Figure 7-25. Figure 7-26 gives comparisons of the 2401 with other magnetic tape units.

• 2415 Magnetic Tape Unit and Control Models 1-6

The IBM 2415 Magnetic Tape Unit and Control (Figure 7-22), like the 2401, reads and writes on half-inch magnetic tape (IBM Series/500, Dynexcel, or equivalent) with data densities of 800 or 1,600 bpi. (MYLAR tape may be used for 800-bpi recording.) The operations of the 2415 are similar to those of a basic 2401, but the 2415 has data rates that are a downward extension of those available with a 2401.

Two, four, or six tape units are available with a 2415, depending on the model. Each tape unit operates independently, but only one can read or write at a time.

MODEL	NO. TAPE UNITS	DATA RATE (BYTES PER SECOND)	DATA DENSITY (BYTES PER INCH)
1	2	15,000	800
2	4	15,000	800
3	6	15,000	800
4	2	30,000	1,600
5	4	30,000	1,600
6	6	30,000	1,600

As with the 2401, the 2415 Models 1-3 use the NRZI method of recording data; Models 4-6 use phase-encoding.

Standard Features

Parity Checking: This is done during tape reading (in both 800- and 1,600-bpi recording) and during read-back check of tape writing (in 800-bpi recording, and in 1,600-bpi recording if the control unit is a 2803-2 with 2420 attachment capability).

Amplitude Checking: In 1,600-bpi recording, the amplitude of the signal is checked against a predetermined threshold level. This check determines whether the signal of the data being recorded is strong enough to permit the data to be subsequently read.

Error Correction: The 2415 Models 4-6, using 1,600-bpi nine-track format, automatically detect and correct single track errors during tape reading. Conventional error recovery routines are applied for all other errors.

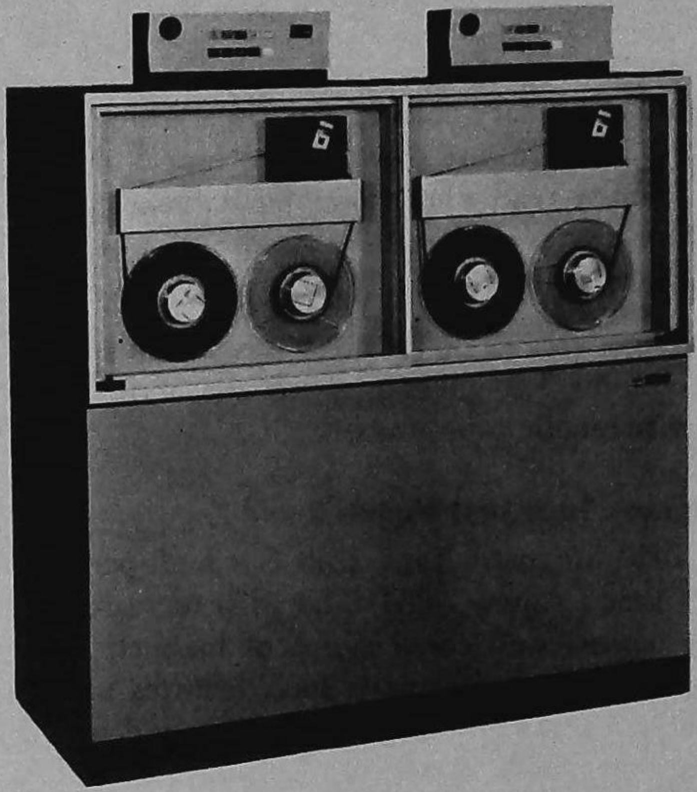


Figure 7-22. IBM 2415 Magnetic Tape Unit and Control Model 1 or 4

Read Backward: As with the 2401, tapes written on any 2400-series tape unit can be read by any other 2400-series tape unit either backward or forward, provided the writing and reading units operate with the same tape density and format. However, the data conversion feature cannot be used when reading seven-track tape backwards.

Quick Release Latches: Each tape unit has quick release latches to facilitate the mounting and removing of tape reels.

Optional Features

Seven-Track, Nine-Track, or Seven-and-Nine-Track Compatibility: These features are basically the same as those available for the 2803 and 2804 Tape Controls. Attachment of any one of these three on a 2415 precludes attachment of the others. Seven-track compatibility enables the 2415 tape unit to write or read seven-track tape; this provides compatibility with tapes used by devices such as the IBM 727, 729, and 7330 Magnetic Tape Units. Nine-track compatibility enables the 2415 tape unit to write or read 800-bpi NRZI tapes in addition to 1,600-bpi tapes. Seven-and-nine-track compatibility (available only on Models 4, 5, and 6) satisfies the requirements of both of the other two features by permitting reading and writing both seven- and nine-track 800-bpi NRZI tapes.

Data Conversion: This feature is the same as the data conversion feature available for the 2803 Tape

Control. This program-controlled feature permits seven-track tape units to read and write data in binary form rather than binary-*coded* form. On a write operation, three 8-bit bytes are converted to four 6-bit tape characters; on a read operation, the sequence is reversed. This feature cannot be used when reading seven-track tapes backwards.

Further characteristics of the 2415 are shown in Figure 7-25. Figure 7-26 gives comparisons of the 2415 with other magnetic tape units.

● 2420 Magnetic Tape Unit Models 5 and 7

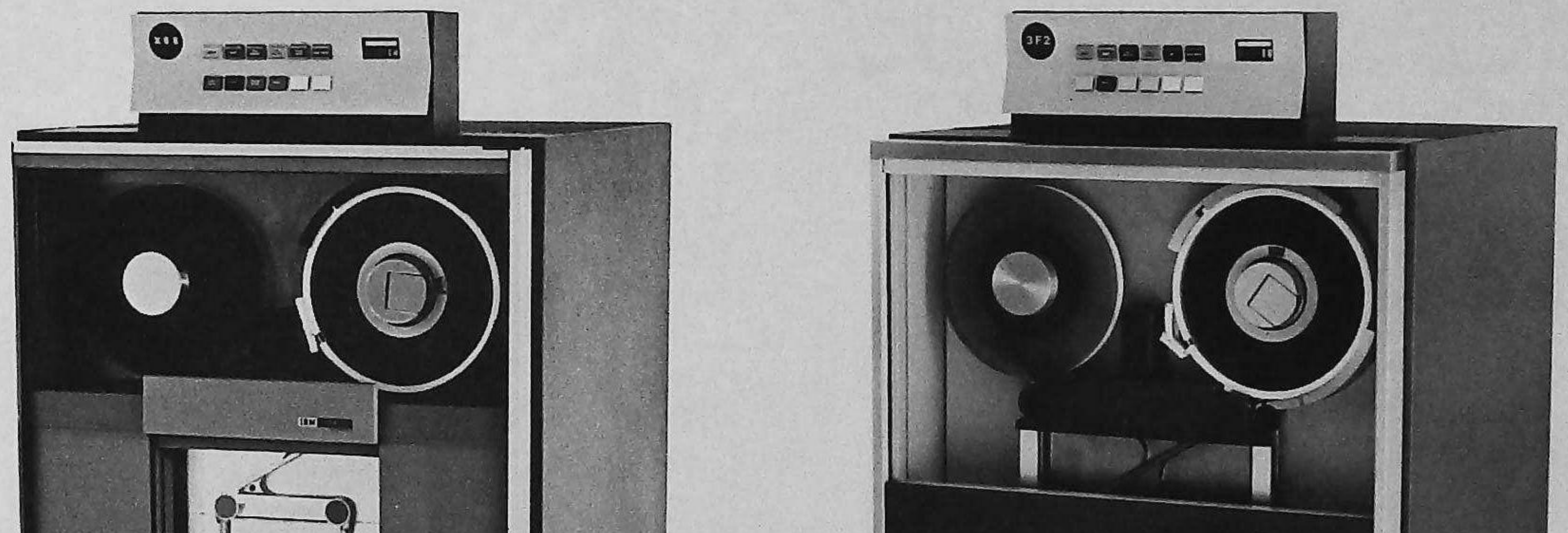
The IBM 2420 Magnetic Tape Unit is a high-performance tape unit (Figure 7-23). The 2420 increases the reliability, speed, and convenience of magnetic tape operations in System/360 with such features as cartridge loading, automatic tape threading, and an advanced tape transport. The 2420 reads and writes data at 1,600 bytes per inch on half-inch magnetic tape (IBM Series/500, Dynexcel, Heavy-Duty, or equivalent) mounted on 8½- or 10½- inch reels.

Cartridge Loading

An optional accessory of the 2420 is the Wraparound Cartridge (Figure 7-24) for standard 10½-inch reels. The cartridge protects tape from dust and the hazards of handling and eliminates reel positioning. Once the cartridge is mounted, the tape automatically threads, feeds, and rewinds on command. The cartridge-enclosed tape reels can be used interchangeably with standard reels and may be removed from the cartridge for use on other 2400-series tape units.

Automatic Threading and Rewind

The 2420 provides reduced setup time because of automatic threading. The only requirements are that the free end of the tape be properly trimmed and that it be positioned on the threader chute. The tape is automatically threaded through the tape path from the



Model 5

Model 7

● Figure 7-23. IBM 2420 Magnetic Tape Units Models 5 and 7

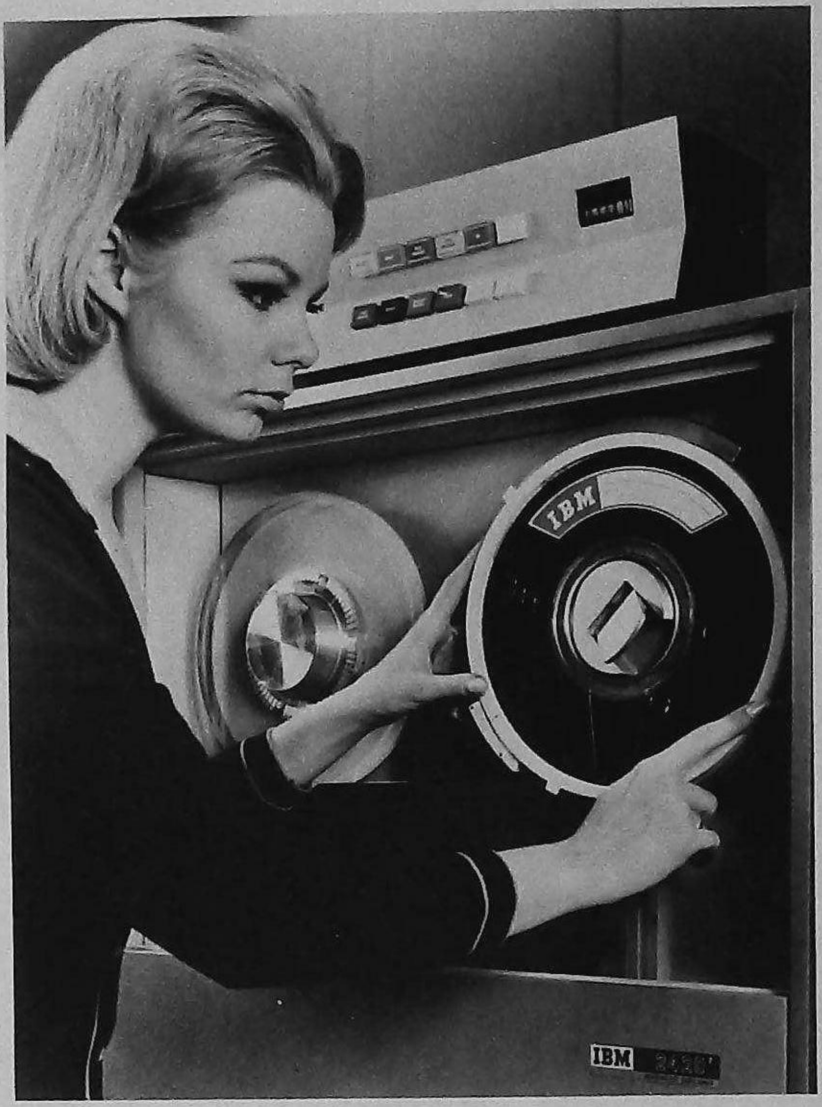


Figure 7-24. IBM 2420 Magnetic Tape Unit Model 7 with Wraparound Cartridge

supply reel to the take-up reel, loaded into the vacuum columns, and positioned at the load point. This operation takes less than 10 seconds. Tape is rewound in the vacuum column at approximately 500 inches per second; therefore, a 2,400-foot reel can be rewound in about 1 minute. Rewind time for less than 2,400 feet of tape is approximately proportional to the amount of tape to be rewound; for example, 1,200 feet of tape is rewound in about 30 seconds and 600 feet is rewound in about 15 seconds.

Advanced Tape Transport

The tape transport for the 2420 uses a minimum number of mechanical parts, thereby increasing reliability and reducing tape wear. A single drive capstan moves the tape forward and backward across the read/write head while the oxide surface of the tape touches only the read/write head and the tape cleaner. During rewind operation, the tape remains in the vacuum columns, resulting in less stress on the tape.

Other Standard Features

Other features of the 2420 are: parity and amplitude checking, phase-coded method of recording data, powered access window, and quick-release latch.

Parity is checked during both tape reading and writing; signal amplitude is checked (against a predetermined threshold level) during tape writing.

Phase-encoded recording permits single track errors (the most common type) to be corrected in flight, resulting in improved throughput. Multiple track errors are indicated to the program. An added benefit is the interchangeability of the phase-encoded tapes among Models 4-6 of the 2401-2415 tape units, as well as Models 5 and 7 of the 2420 Magnetic Tape Unit.

The power window and the quick-release latch facilitate operator functions. The power window closes automatically during a load operation and opens automatically following the completion of a rewind-and-unload command. The quick-release latch facilitates the mounting and removal of the tape reel and cartridge.

Further characteristics of the 2420 are shown in Figure 7-25. Figure 7-26 gives comparisons of the 2420 with other magnetic tape units.

Tape Control and Unit Switching

A 2803 Tape Control Model 2 (with a serial number above 14000 but below 30000 and with the appropriate 2420 attachment feature) can control as many as eight tape units in any combination of 2420 Models 5 and 7 and 2401 Models 4-6. With additional features, 2401 Models 1-3 can be included in this combination. Switching among these units is provided by the 2816 Switching Unit Model 1.

	IBM 2401						IBM 2415		IBM 2420	
Characteristic	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Models 1-3	Models 4-6	Model 5	Model 7
Data Rate (bytes per second)	30,000	60,000	90,000	60,000	120,000	180,000	15,000	30,000	160,000	320,000
Tape Speed (inches per second)	37.5	75	112.5	37.5	75	112.5	18.75	18.75	100	200
Standard Density (bytes per inch)	800	800	800	1600	1600	1600	800	1600	1,600	1,600
Nominal Interblock Gap (inches)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Nominal Interblock Gap Time (milliseconds)	16	8	5.3	16	8	5.3	32	32	6	3
Rewind Time (minutes)	3	1.4	1	3	1.4	1	4	4	1.2	10
Rewind and Unload Time (minutes)	2.2	1.5	1.1	2.2	1.5	1.1	4	4	1.3	1.1
Tape Width (inches)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Standard Number of Tracks	7 or 9	7 or 9	7 or 9	9	9	9	7 or 9	9	9	9

● Figure 7-25. Characteristics of IBM 2401, 2415, and 2420 Magnetic Tape Units

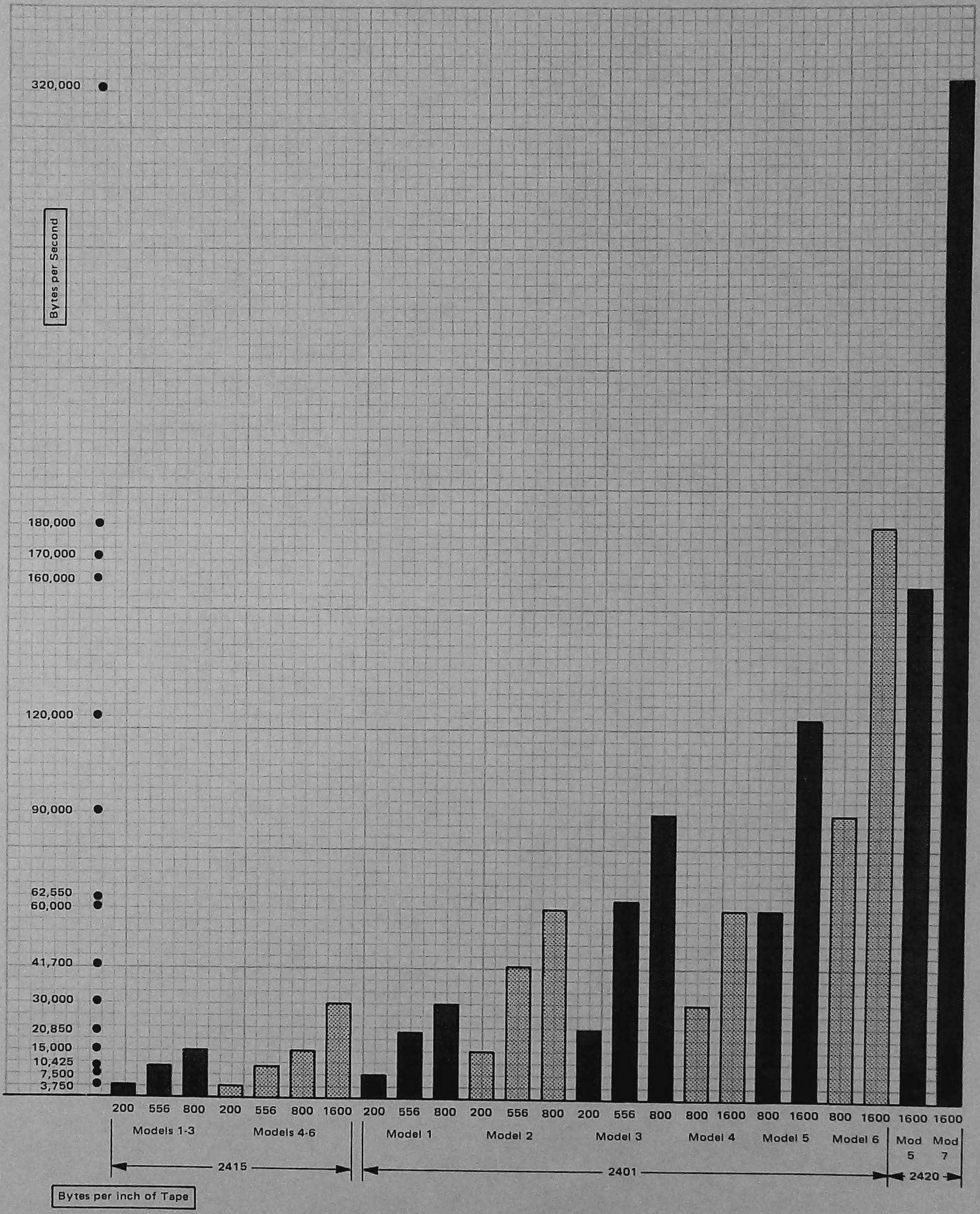


Figure 7-26. Comparative Data Rates of Magnetic Tape I/O Used with System/360

• 2803 Tape Control Models 1 and 2; 2804 Tape Control Models 1 and 2

The IBM 2803 and 2804 Tape Controls (Figure 7-27) can both handle as many as eight tape units. The 2803 is a one-channel control unit and requires one control-unit position on a channel. The 2804, however, is a two-channel control unit and requires one control-unit position on each of two channels. The 2804 attaches to two channels in a manner that permits a read operation on one tape unit to be overlapped with a simultaneous write operation on another unit.

The two units are each available in two models (1 and 2) and are similar in what they control:

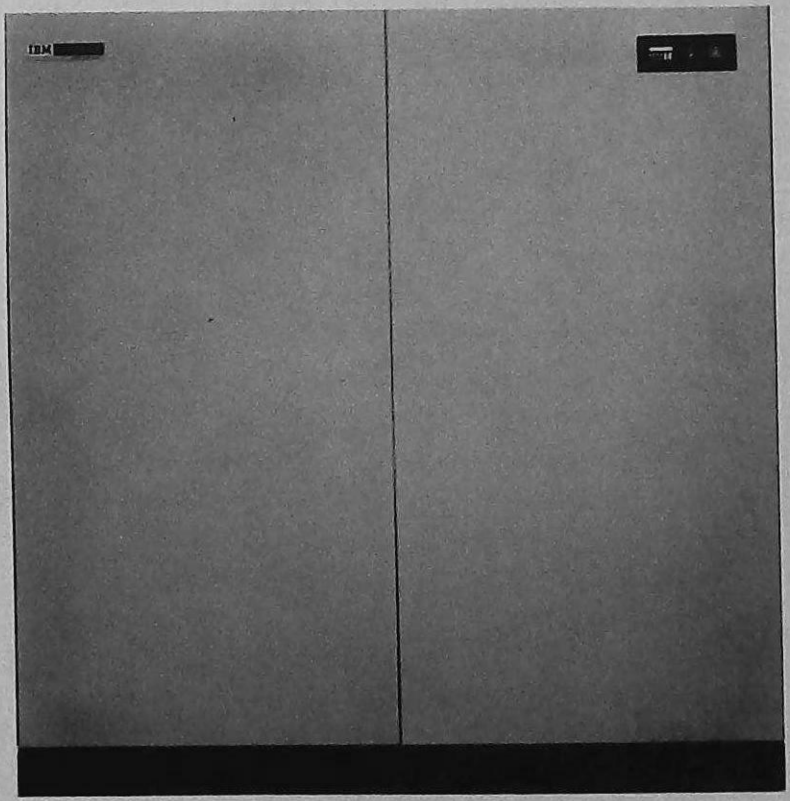
Model 1 of the 2803 and 2804 controls 800-bpi 2401 tape units Models 1-3.

Model 2 of the 2803 and 2804 also controls 2401 tape units Models 1-3, provided the 2803 or 2804 is equipped with either the nine-track or seven-and-nine-track compatibility feature. In addition to this, the Model 2 of the 2803 and 2804 controls the 1600-bpi 2401 tape units Models 4-6.

Model 2 of the 2803 can also control 2420 tape units Models 5 and 7, provided the 2803 has a serial number 14001-29999 and is equipped with a 2420 attachment.

Optional Features

Seven-Track Compatibility: This feature enables a 2401 Model 1-3 to write or read seven-track tape at 200, 556, or 800 characters per inch; this provides tape compatibility with devices such as the IBM 729 and 7330 Magnetic Tape Units. The seven-track compatibility feature is required if any attached 2401 Model 1-3 has a seven-track head. As part of the feature, a code translator is included to translate the BCD interchange code to EBCDIC.



• Figure 7-27. IBM 2803 or 2804 Tape Control

Nine-Track Compatibility: In keeping with the flexibility that provides for any practical variation in requirements, an optional nine-track compatibility feature is available for Model 2 of the 2803 and 2804 to allow the reading and writing of nine-track tape at 800 bpi as well as 1,600 bpi. This feature is required when:

1. Any attached 2401 Model 1-3 has a nine-track head.
2. Any attached 2401 Model 4-6 has the dual-density feature.

Seven- and Nine-Track Compatibility: The seven-track and nine-track compatibility features are mutually exclusive on the same tape control. However, instead of either feature, an optional seven- and nine-track compatibility feature can be installed on Model 2 of the 2803 or 2804 to provide all the advantages of both features.

Sixteen-Drive Addressing (2803 Models 1 and 2): This feature enables a 2803 to address as many as sixteen 2401 Magnetic Tape Units that are attached to the 2803 through 2816 Switching Unit Model 1's. This feature is not needed unless a 2803 must have the capability of addressing more than eight tape units.

Data Conversion: This program-controlled feature, available to tape controls with seven-track compatibility, permits seven-track tape units to read and write data in binary form rather than binary-coded form. On a write operation, three 8-bit bytes are converted to four 6-bit characters; on a read operation, the sequence is reversed. This feature cannot be used when reading seven-track tapes backwards.

2420 Attachment (2803 Model 2): When equipped with this feature, the 2803 can attach and control any combination of 2420 Models 5 and 7 and 2401 Models 4-6 that does not exceed eight. (2401 Models 1-3 can be included in this combination if appropriate features are installed on the 2803 Model 2). Field installation of the 2420 attachment can be made only on a 2803-2 with a serial number above 14000 but below 30000.

Remote Switch Attachment (2803 Model 1): This attachment permits the switching of the 2803-1 between two channels in a System/360 Model 67-2 or in a multiprocessor System/360 Model 65.

2816 Switching Unit Model 1

The IBM 2816 Switching Unit (Figure 7-28) provides a means of assigning a common group of magnetic tape units to more than one tape control, thus allowing

Figure 7-28. IBM 2816 Switching Unit

still more flexibility in tape configurations and the minimizing of such configurations: for instance, by allowing a control to have access to a tape unit that is attached to another control. The 2816 introduces other advantages, including such unbalanced sort operations as three inputs to six outputs or vice versa, with the consequent minimum of time for manual mounting and demounting of reels.

With the 16-drive addressing feature installed on the appropriate tape controls and the use of two IBM 2816 Switching Units, a maximum of 16 tape units may be controlled in common by a maximum of four tape controls. The minimum is control of four tape units by two tape controls; any combination between the minimum and maximum is available. For more than eight tape units, the second switching unit is required. The switching of tape units on the 2816 is completely under program control, on a per-record basis.

Model 1 of the switching unit is used for switching tape units in any mixture of 2401 Models 1-6 and 2420 Models 5 and 7; however, the 2816 requires a tape unit intermix feature for switching 800-bpi tape units to a 2803 Model 2.

The tape controls involved must be either 2803 Model 1 or 2803 Model 2; the 2816 cannot switch both Models 1 and 2 on the same system.

If the 16-drive addressing feature is not installed on a tape control, it can control only the first eight tape units in the tape pool.

2495 Tape Cartridge Reader

The IBM 2495 Tape Cartridge Reader (Figure 7-29) transfers data stored on magnetic tape cartridges to an IBM System/360. The 2495 is program-controlled and reads tape-stored data at 900 characters per second; each character is parity-checked as it is transferred to the channel. As many as 12 tape cartridges, each containing 100 feet of 16-millimeter sprocketed magnetic tape, can be loaded into the 2495 feed (auto loader) at one time. Each tape can hold up to 23,000 characters of information (equivalent to about 300 fully punched cards). The 2495 accepts cartridges generated on either the IBM 50 Magnetic Data Inscriber or the IBM Magnetic Tape SELECTRIC® Typewriter (MT/ST) System.

Initially, the tape cartridges are placed in the auto loader. When the start button is pressed, the first cartridge is mounted in the tape read station and is prepared for reading.

Each subsequent cartridge is automatically loaded. Tape is read and rewound at about 45 inches per second under program control. After a tape has been read and rewound, it is automatically unloaded, placed in the stacker, and the following cartridge is loaded – all within approximately 5 seconds.

The IBM 50 Magnetic Data Inscriber, an independent device, records information in System/360-compatible code on nine tracks across the width of 16-millimeter tape. It uses cartridges that are physically similar to those used with the IBM MT/ST System; because of differing magnetic properties, however, the tapes are not to be used interchangeably. On the IBM 50, information is magnetically inscribed on tape by means of a keyboard similar to that of an IBM card punch. The operator can select from as many as eight data formats from a pre-punched program card. The IBM 50 will also verify tapes made on other IBM 50 units.

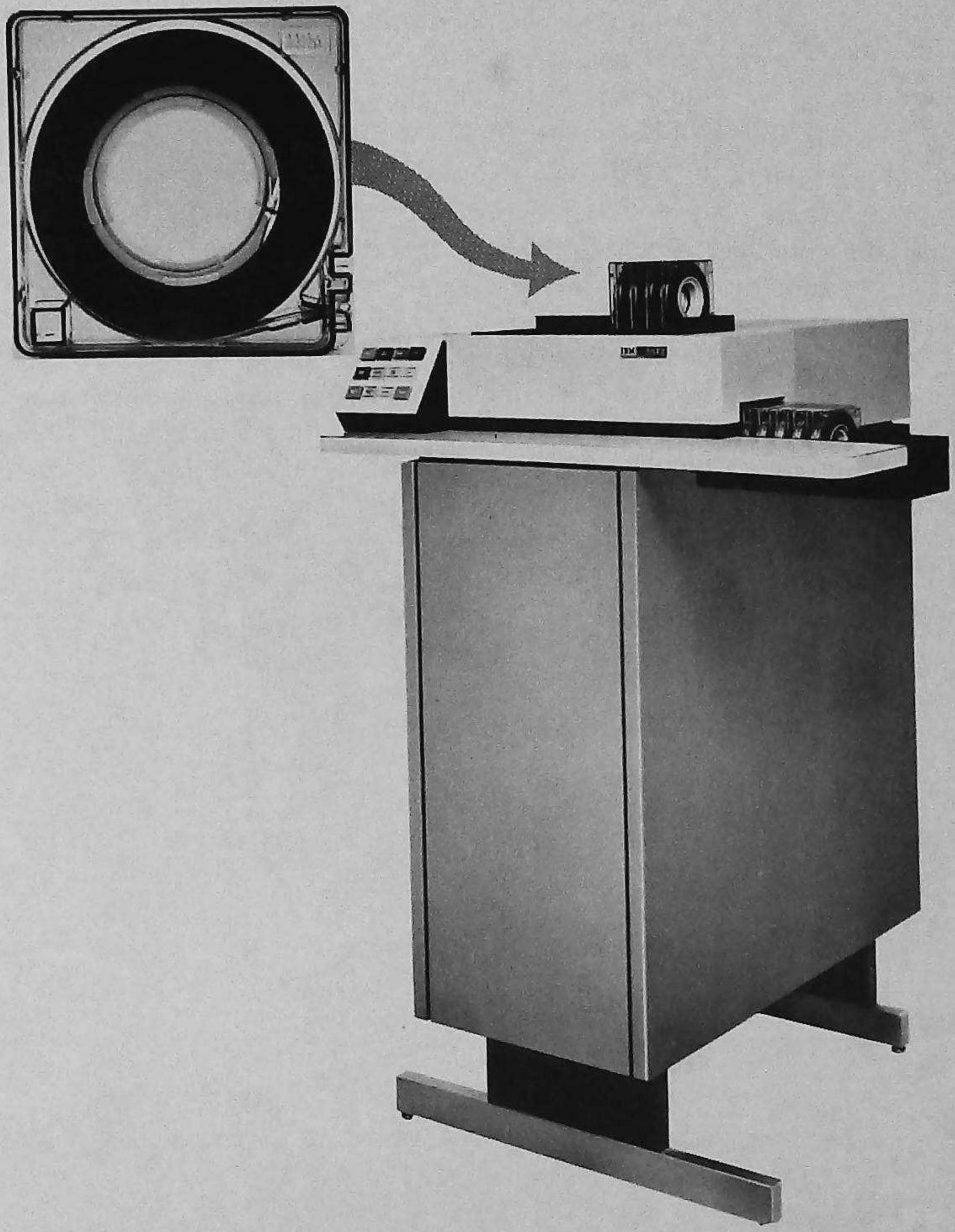


Figure 7-29. IBM 2495 Tape Cartridge Reader and Magnetic Tape Cartridge

Manual Controls

1052 Printer-Keyboard Models 3, 5, 6, 7, and 8

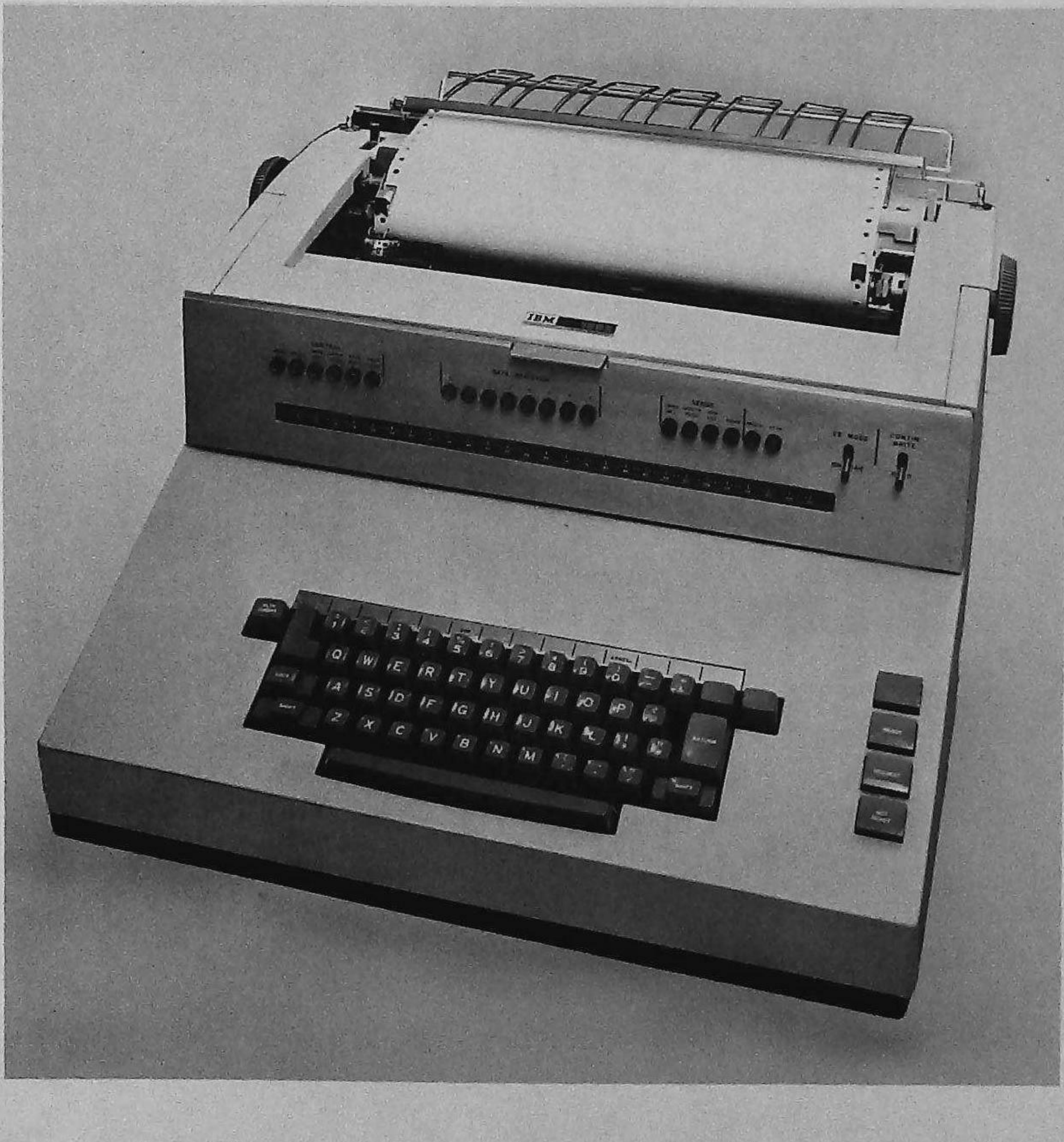
The IBM 1052 Printer-Keyboard (Figure 7-30) can be attached to the system for communication between the operator and the system: for example, such operator-program changes as program checking or correcting and job logging. Facilities are provided for interrupting the CPU and for signaling the end of the operator's transmission.

The typewriter-style keyboard and the printing function can be used independently: the keyboard for system input, and the printer for computer output. The 1052 has a stationary carriage and a spherical, interchangeable printing element.

The 1052 must be connected to a System/360 Model 30 via an IBM 1051 Control Unit. The 1052 may be operated as the only device connected to the 1051, or other local I/O devices from an IBM 1050 Data Communications System may also be connected to the 1051. Remote 1050 systems can also be connected to the 1051, but may be operated only off-line.

Models 3, 5, 6, 7, and 8 of the 1052 can be attached to System/360 and operated under the control of its program. Models 7 and 8 are as shown in Figure 7-30. The appearance of Models 3, 5, and 6 varies in small details, in keeping with the presence of tabulation, backspacing, single/double indexing, paper releasing, ribbon shifting, and line feeding functions in those models. (A program with commands for such functions also runs on Models 7 and 8, but the functions are not performed.)

The nominal speed of Models 3, 5, 6, and 8 is 14.8 characters per second; of Model 7, 15.5 characters per



• Figure 7-30. IBM 1052 Printer-Keyboard second. For Models 3, 5, and 6, line spacing (either 6 or 8 to the inch), character spacing (either 10 or 12 to the inch), and the font of each printing sphere are all as specified by the customer; Models 7 and 8 differ in that line spacing is set at 6 lines per inch and character spacing is set at 10 characters per inch. The maximum line length for Models 3, 5, and 6 is 13 inches, for up to 130 or 156 characters at, respectively, 10 or 12 per inch; for Models 7 and 8, it is 12.5 inches, for up to 125 characters.

The five models differ also in their electrical connections, and these correspond to the four different ways in which the 1052 may be connected:

Model 3 attaches to a System/360 channel via the 1051 Model 1. (This is the only configuration that permits the connection of remote 1050 systems.)

Model 5 attaches to a System/360 channel via the 1051 Model N1 when other local I/O devices of a 1050 system are to be attached. The Model 5 provides the additional switches needed.

Model 6 or 8 attaches to a System/360 channel via the 1051 Model N1 when *no* other devices of a 1050 system are to be attached.

Model 7 attaches to a System/360 channel via a 1052 adapter, which can be installed in a CPU or within an IBM 2150 Console, the location depending on the System/360 model.

Only a Model 7 is attachable without a 1051 Control Unit or to a system other than the Model 30. Attachment of a 1052 via the 1051 does not require a control-unit position of a channel. The Model 7 requires a control-unit position on a channel.

Only the standard features that are useful or necessary in a system environment are available. A pin-fed paper with 13⅛-inch width from hole to hole must be used, and the left and right margin stops are fixed.

A number of special features are available for the 1052 Models 3, 5, and 6, including an accelerated carrier return for speeding the carrier return time to about half that of a standard 1052, and a forms feed that provides control over the vertical movement of continuous paper forms.

For an installed Model 6 and its associated 1051 Model N1, the user may specify a functional compatibility with Model 8. In that case, the accelerated carrier return feature, if installed on the Model 6, can be continued; and if the Model 6 was installed with 8 lines per inch and/or 12 characters per inch spacing, these functional differences will also remain.

An IBM 1053 Printer Model 1 can be installed in place of a 1052 Model 6 or 8 or together with (or in place of) a 1052 Model 5. The 1053 (Figure 7-40) is similar to the 1052 but has no keyboard. It is further described under "Printers."

1051 Control Unit Models 1 and N1

The IBM 1051 Control Unit Model N1 provides control circuitry and attachment facilities for (1) a 1052 Model 6 or 8 or 1053 Model 1 alone, or (2) a 1052 Model 5 and/or 1053 Model 1 and other local devices of a 1050 system. Including the 1052, the maximum local configuration is four devices, with alternatives in three:

1. One 1053 Printer Model 1
2. One 1052 Printer-Keyboard Model 5 or a second 1053 Printer Model 1
3. One of the following:
   a. 1054 Paper Tape Reader
   b. 1056 Card Reader
   c. 1092 Programmed Keyboard
   d. 1093 Programmed Keyboard
   e. tandem 1092/1093 Programmed Keyboards
4. One 1055 Paper Tape Punch or 1057 Card Punch

The optional home component recognition feature permits any of the locally attached 1050 devices to be turned on and off under the control of characters in the data field rather than by keys at the 1052 keyboard.

Model 1 of the 1051 control unit attaches a 1052 Model 3 and provides for the same local 1050 devices as Model N1, and can also attach remote 1050 systems via appropriate data sets and communication lines.

In 1050 language, local operations are termed "home loop." All operations of the local 1050 devices are therefore in home loop; and may be either on-line or off-line. Line loop (communication with remote 1050 systems) is strictly off-line.

The 1051 Model 1 requires the master station feature to communicate with the remote 1050 systems and can – if an adequate configuration of local 1050

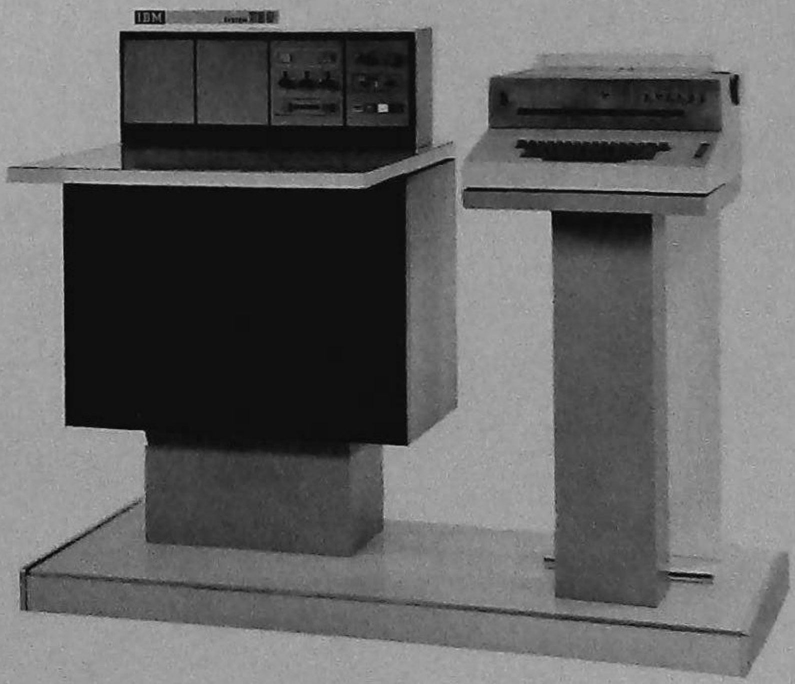


Figure 7-31. IBM 2150 Console and 1052 Printer-Keyboard

devices are attached to the 1051 – poll, address, and communicate off-line with up to 25 such 1050 systems. This operation is the same as that of a 1050 system which has no connection to the System/360.

2150 Console

The IBM 2150 Console provides the IBM System/360 Models 50-91 with a duplication of the operator's controls at a station removed from the CPU (Figures 6-8 and 7-31). A location is provided on the freestanding 2150 for mounting one or two operator control panels. Two panels enable one 2150 to control either of two systems in a multisystem.

The 2150 Console includes an operator's chair, a program-controlled audible alarm, and an adapter for the IBM 1052 Printer-Keyboard Model 7. The 1052 communicates with only the CPU to which the 2150 Console is attached (via a channel).

Optical Readers

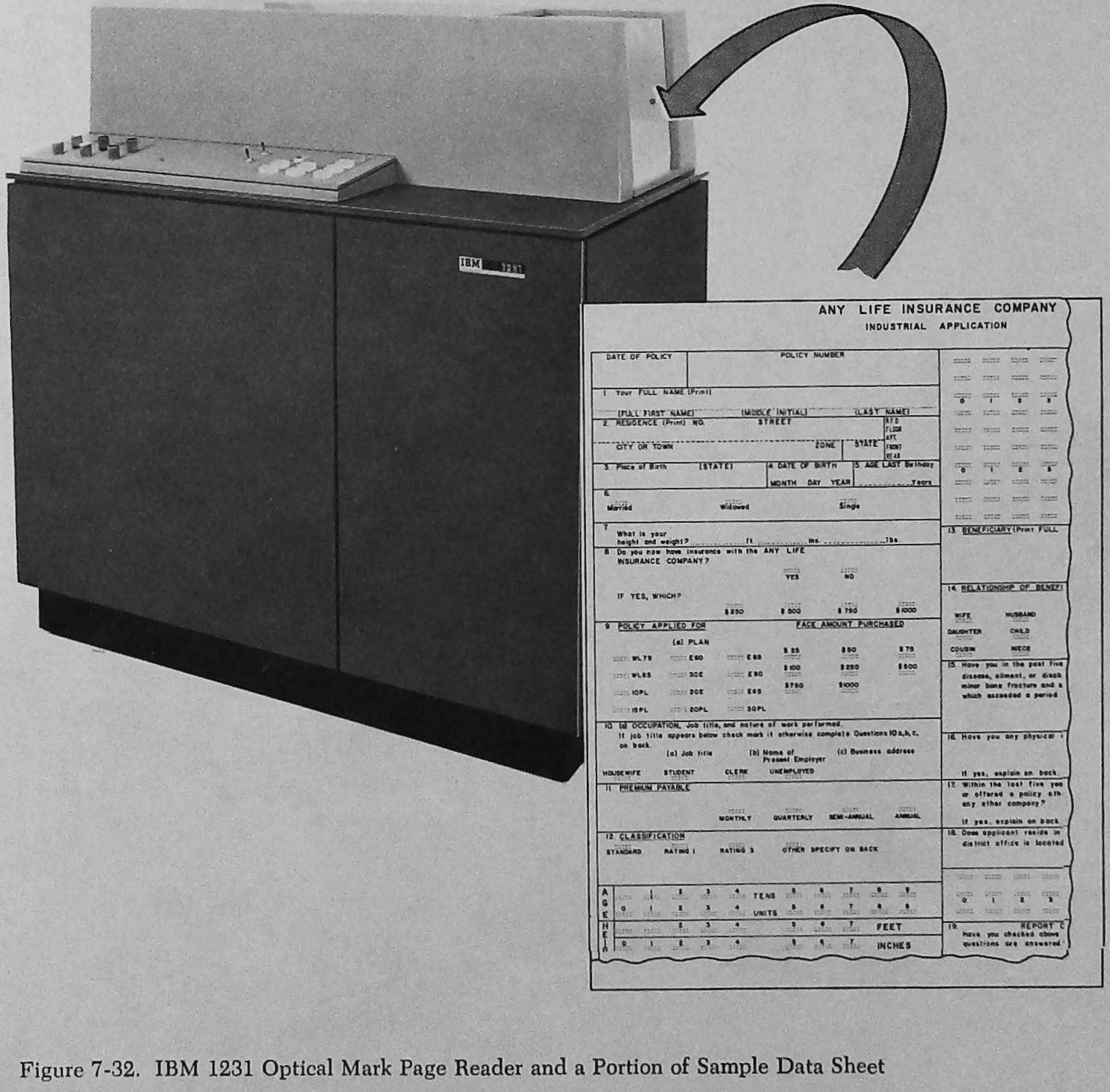
• 1231 Optical Mark Page Reader Model N1

The IBM 1231 Optical Mark Page Reader Model N1 (Figure 7-32) reads marked data, one of the simplest forms of data recording. The 1231 can thereby eliminate steps normally required (such as manual card punching and verifying) to prepare input for data processing. It also opens possibilities in data recording and computer entry that were previously considered impractical because of time or volume considerations.

The 1231 reads marks made on 8½-by-11-inch data sheets. The marks may be made by ordinary (No. 2) pencils, a 1403 Printer, a 1443 Printer Model 1 or 2 (with a 52- or 63-character type bar with arrangement A, H, or K), or a 1443 Printer Model N1 or 2203 Printer Model A1 (with a 52- or 63-character type bar). To enable the 1231 to read machine-made marks, the printer must be equipped with an enlarged dash to replace the standard dash.

The 1231 feeds data sheets through the reader from a 600-sheet hopper and stacks them (in reverse order) in a 600-sheet stacker or (if an error is detected) in a separate 50-sheet stacker. The 1231 can read as many as 2,000 sheets per hour, .or about one sheet every 1.8 seconds. With as many as four 1231's permitted per system, total throughput can be correspondingly increased.

The data sheets read by the 1231 are flexible input documents. Capable of having as many as 1,000 preprinted marking positions per side, the sheets can be designed to meet different input requirements by the appropriate selection and labelling of the mark positions. Because of this design flexibility, data sheets are adaptable to a variety of applications in government, industry, business, and institutional organizations, such



ANY LIFE INSURANCE COMPANY
INDUSTRIAL APPLICATION

DATE OF POLICY
POLICY NUMBER
1 Your FULL NAME (Print)
(FULL FIRST NAME) (MIDDLE INITIAL) (LAST NAME)
2 RESIDENCE (Print) NO. STREET
RFD
FLOOR
APT.
FRONT
REAR
CITY OR TOWN ZONE STATE
3 Place of Birth (STATE)
4 DATE OF BIRTH
MONTH DAY YEAR
5 AGE LAST Birthday
.... Years
6
Married Widowed Single
7
What is your height and weight? .... ft .... ins. .... lbs.
8 Do you now have insurance with the ANY LIFE INSURANCE COMPANY?
YES NO
IF YES, WHICH?
$250 $500 $750 $1000
9 POLICY APPLIED FOR
(a) PLAN
WL79 E60 E68
WL65 30E E80
10PL 20E E65
15PL 20PL 50PL
FACE AMOUNT PURCHASED
$25 $50 $75
$100 $250 $500
$750 $1000
10 (a) OCCUPATION, Job title, and nature of work performed.
If job title appears below check mark it otherwise complete Questions 10 a, b, c. on back.
(a) Job title
(b) Name of Present Employer
(c) Business address
HOUSEWIFE STUDENT CLERK UNEMPLOYED
11 PREMIUM PAYABLE
MONTHLY QUARTERLY SEMI-ANNUAL ANNUAL
12 CLASSIFICATION
STANDARD RATING I RATING 3 OTHER SPECIFY ON BACK
AGE
1 2 3 4 TENS 5 6 7 8 9
0 1 2 3 4 UNITS 5 6 7 8 9
HEIGHT
2 3 4 5 6 7 FEET
0 1 2 3 4 5 6 7 INCHES

0 1 2 3
0 1 2 3
13 BENEFICIARY (Print FULL
14 RELATIONSHIP OF BENEFI
WIFE HUSBAND
DAUGHTER CHILD
COUSIN NIECE
15 Have you in the past five
disease, ailment, or disab
minor bone fracture and a
which exceeded a period
16 Have you any physical
If yes, explain on back.
17 Within the last five yea
or offered a policy oth
any other company?
If yes, explain on back
18 Does applicant reside in
district office is located
0 1 2 3
19 REPORT C
Have you checked above
questions are answered

Figure 7-32. IBM 1231 Optical Mark Page Reader and a Portion of Sample Data Sheet

as order entries, questionnaires, sales reports, inventories, meter readings, multiple-choice tests, and traffic surveys.

1285 Optical Reader

The 1285 Optical Reader (Figure 7-33) can quickly read large volumes of data from continuous rolls of paper (journal rolls, such as cash-register and adding-machine tapes), bypassing the transfer of such data to punch-cards for computer entry. The speed, ease of operation, and efficiency of the 1285 are especially important in areas such as sales auditing, inventory control, and retail management decision-making.

The 1285 reads the characters and symbols of the IBM 1428 font (Figure 7-51): the numbers 0-9; the letters C, N, S, T, X, and Z; and the slash-dash symbol ⌿. With a special feature, the 1285 can also read the NCR Optical Font (NOF); switching from one type style to the other is under operator control.

The tape read by the 1285 may be form $1\frac{5}{16}$ to 3½ inches wide and 3 to 200 feet long, with as many as 32 characters per line.

Unreadable characters are automatically rescanned. They can be corrected on-line, or the line containing the unreadable characters may be marked under program control for correction off-line. In the on-line correction mode, the 1285 stops and displays an unreadable character on the display tube (Figure 7-33). The operator can either correct the character from the keyboard or reject it as unrecognizable. The program may then cause the 1285 to display the full line for review of the rejected character in context, and entry of the full line via the keyboard. Certain unreadable lines may also be entered by this method.

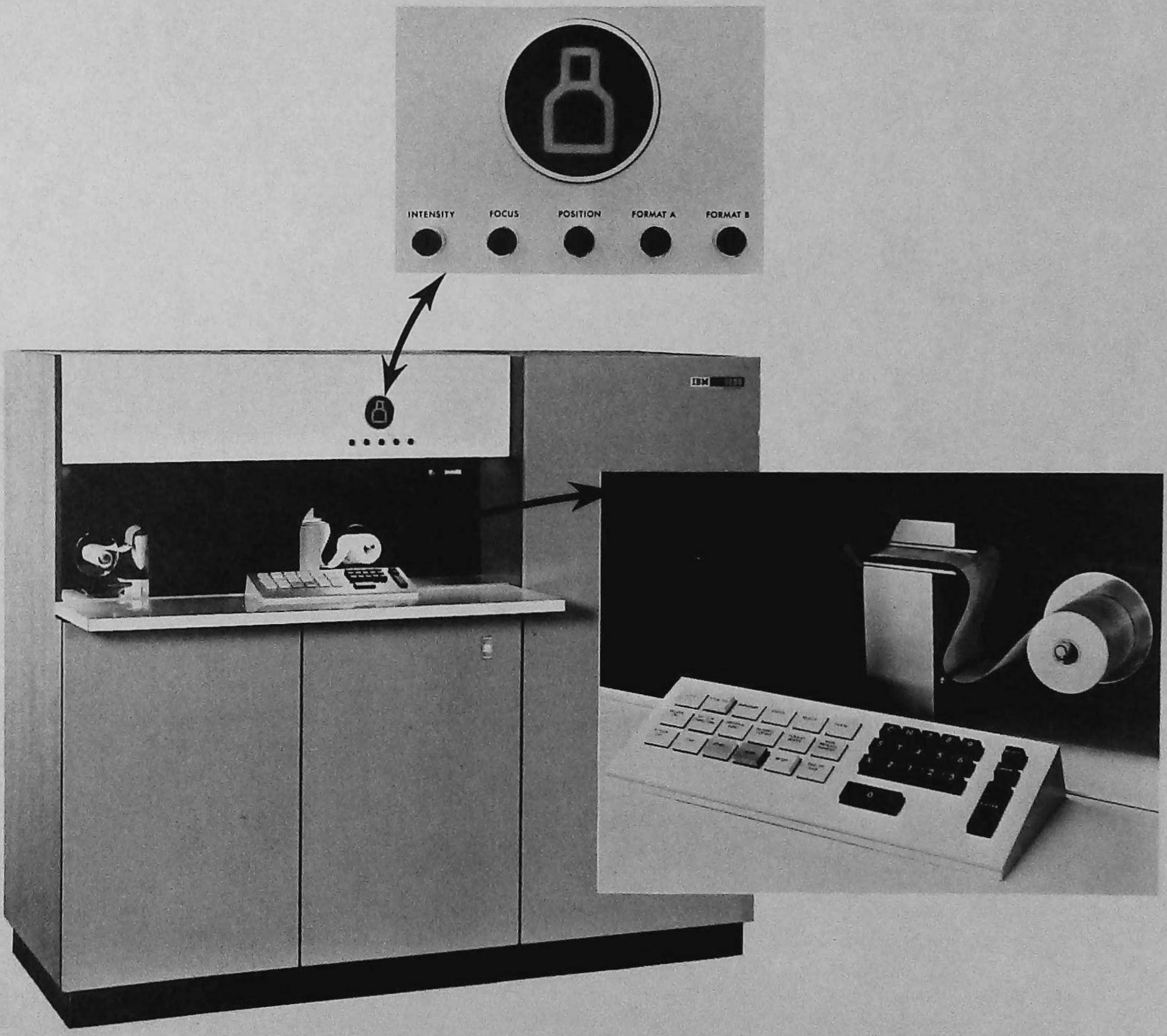


Figure 7-33. IBM 1285 Optical Reader

The optimum reading speed of the 1285 can be calculated from a formula that takes into consideration such factors as the tape width, the number of lines per inch and characters per line, the type style, and the margin width. For example, using two-inch-wide tape with ten characters per line, four lines per inch, and 0.2 inches from tape edge to first character, the 1285 can optimally read about 2,030 lines per minute in IBM 1428 font or about 1,970 lines per minute in NOF.

Using the same factors, a continuously-written roll 200 feet long can be read in slightly less than 5 minutes; actual throughput is affected by on-line correction and the user's program.

The operator can control, with a dial setting, so-called descriptive and quantitative fields to be scanned within the lines.

The printed paper is carried by a flat belt past a scan window and wound tightly onto a powered take-up spindle. A self-threading mechanism enables the operator to load a new tape in about 6 seconds. Efficiency in sustaining 1285 throughput is increased if short rolls, down to the minimum acceptable length of 36 inches, can be spliced together to make up a length near the maximum of 200 feet.

As many as eight 1285's can be used simultaneously with a System/360.

● 1287 Optical Reader Models 1, 2, 3, and 4; 1288 Optical Page Reader Model 1

The IBM 1287 Optical Reader (Figure 7-34) and the 1288 Optical Page Reader (Figure 7-35) can read data from documents with different formats, orientations, types of data, and field lengths. The 1287 and 1288 can eliminate the need for several input conversion steps (for example, card punching, verifying, and taping), thereby providing substantial reductions in data preparation costs and improving overall system efficiency.

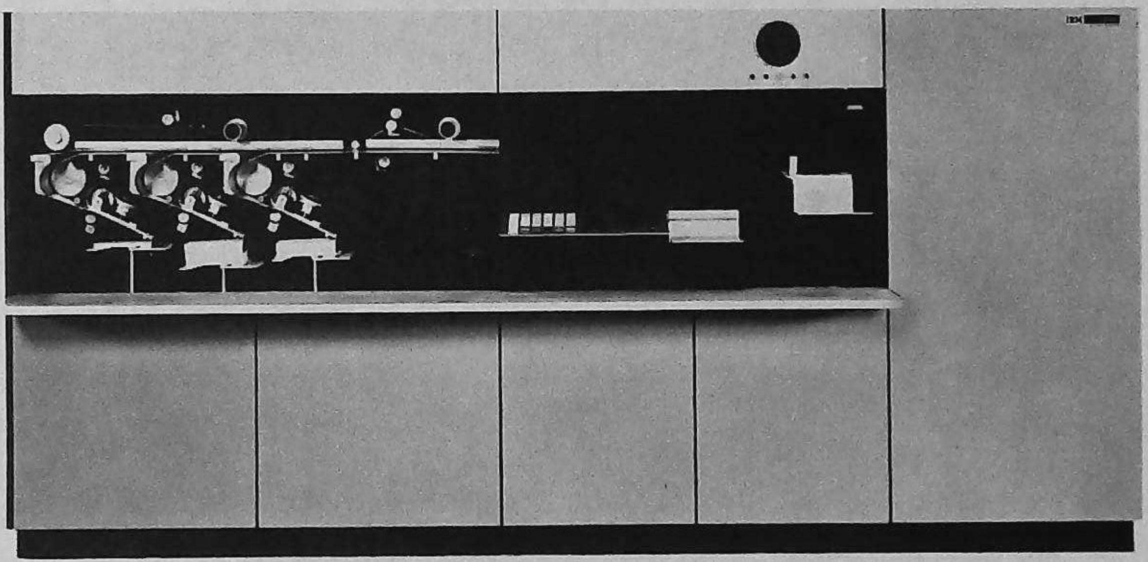
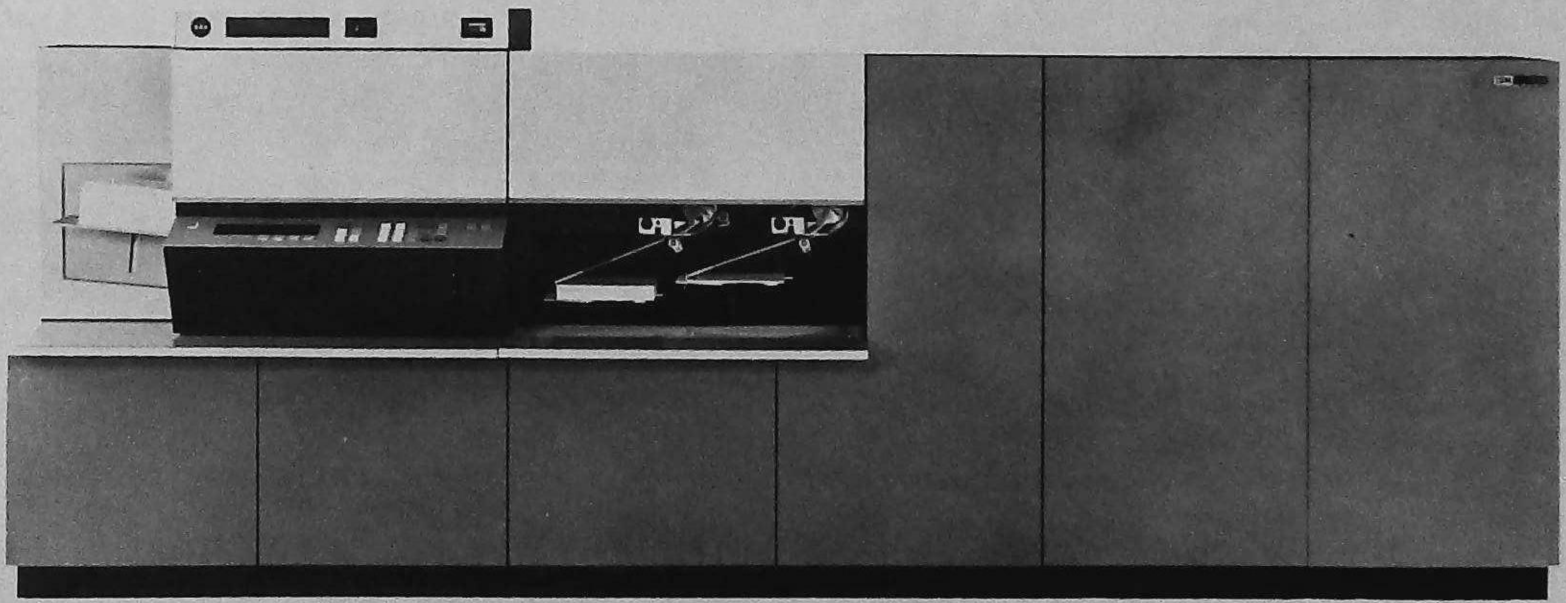


Figure 7-34. IBM 1287 Optical Reader



● Figure 7-35. IBM 1288 Optical Page Reader

The 1287 or 1288 enables the data of source documents to be organized in fixed- or variable-length fields, in columns or rows, and to be read in any sequence. With special features, the 1287 and 1288 can read hand-printed and pencil-marked data, in addition to machine-printed or typed data.

1287 Optical Reader Models 1, 2, 3, and 4

The IBM 1287 is a versatile optical reader; it can read data from both journal rolls (adding-machine and cash-register tapes) and cut-form documents, in a variety of widths and lengths:

	WIDTH		LENGTH	
	MIN	MAX	MIN	MAX
Cut-Form Documents	2¼ in.	3½ in.	3 in.	9 in.
Tapes	1$\frac{5}{16}$ in.	4½ in.	3ft	200 ft*

*If a tape is 3½ inches or wider, the maximum length is 175 ft.

Rates of Processing Data (Throughput): The speed of document processing depends primarily on the size of each document and the number of characters and fields to be read, and is calculated from formulas. Other variables are the type of data being read (machine-printed, hand-printed, or pencil-marked), printed-character registration or alignment, use of on-line correction, and the organization of the processing program.

Typical rates are approximately 665 three-inch documents per minute (reading one field of 20 machine-printed characters) and approximately 100 six-inch documents per minute (reading 50 fields of hand-printed characters).

Journal-roll throughput depends primarily on the number of characters per line and the number of lines per inch. For example, a cash register tape 2 inches wide with four 10-character lines per inch can be read at about 3,300 lines per minute.

The optimum tape reading speeds can be calculated from a formula that takes into consideration factors such as the tape width, the number of lines per inch and characters per line, the type style, and the margin width. Actual throughput, however, may be less than the calculated optimum because of factors such as on-line correction, line rescan, marking of lines containing unreadable characters, and the user's program.

Character Recognition: The 1287 reads alphameric type and symbols that are compatible with both the U.S.A. Standard Character Set for Optical Character Recognition (USASCSOCR) font Size A and the International Standards Organization Standards on Optical Character Recognition font (ISO OCR-A Size 1).

The 1287 has a selection of fonts to choose from (Figure 7-36). It can have either the IBM 1428 font or the USASCSOCR numeric font subset sizes A and C as a standard feature, or the two together as a special feature. Other fonts and features that may be added to provide the 1287 with expanded reading capability include:

NCR Optical Font (NOF)
Farrington Selfchek* 7B font
Numeric handwriting
Optical mark reading
Expanded symbol set

When the combined 1428 and USASCSOCR fonts feature is used, the 1287 can read each font separately in pre-identified fields in a document. Selection of the font to be read for a specific field or document type is under program control; however, when journal rolls are read on Models 2 and 4, font selection (1428 or USASCSOCR-A) is under operator control.

The NCR Optical Font (NOF) feature permits 1287 Models 2 and 4 to read journal tapes written in NOF. The reading of this type style and IBM 1428 or USASCSOCR-A type style is interchangeable and is controlled by the operator.

Farrington Selfchek 7B font feature permits reading characters imprinted on documents by credit plate imprinters.

The numeric handwriting feature permits the 1287 to read handprinted numbers and letters (0-9 and C, S, T, X, and Z, blockprinted with a No. 2 pencil or with HB lead), and numbers preprinted in Gothic $\frac{3}{16}''$ font.

Optical mark reading permits the 1287 to recognize penciled lines entered as data. The marks (made with a No. 2 pencil) may be vertical, slanted 45 degrees, or horizontal.

The expanded symbol set increases the reading capability of 1287 Models 3 and 4 by enabling them to read the following symbols created by the IBM SELECTRIC® typewriter or its equivalent:

+ = { } % ? ” ’

When the 1287 encounters a character it does not recognize, it automatically initiates a rescan. If the character is not recognized after 10 rescans, the 1287 either displays the character on a cathode-ray tube for keyboard (on-line) correction by the operator, or bypasses the character and sends a substitute character to storage for later (off-line) correction, then goes to the next character. When journal rolls are read on Models 2 and 4, the operator can correct unrecognizable characters on-line, or the lines containing unrecognizable characters are marked for off-line correction.

Serial Numbering: An optional serial numbering feature permits the 1287 to number documents sequentially from 00000 to 99999; however, the printing

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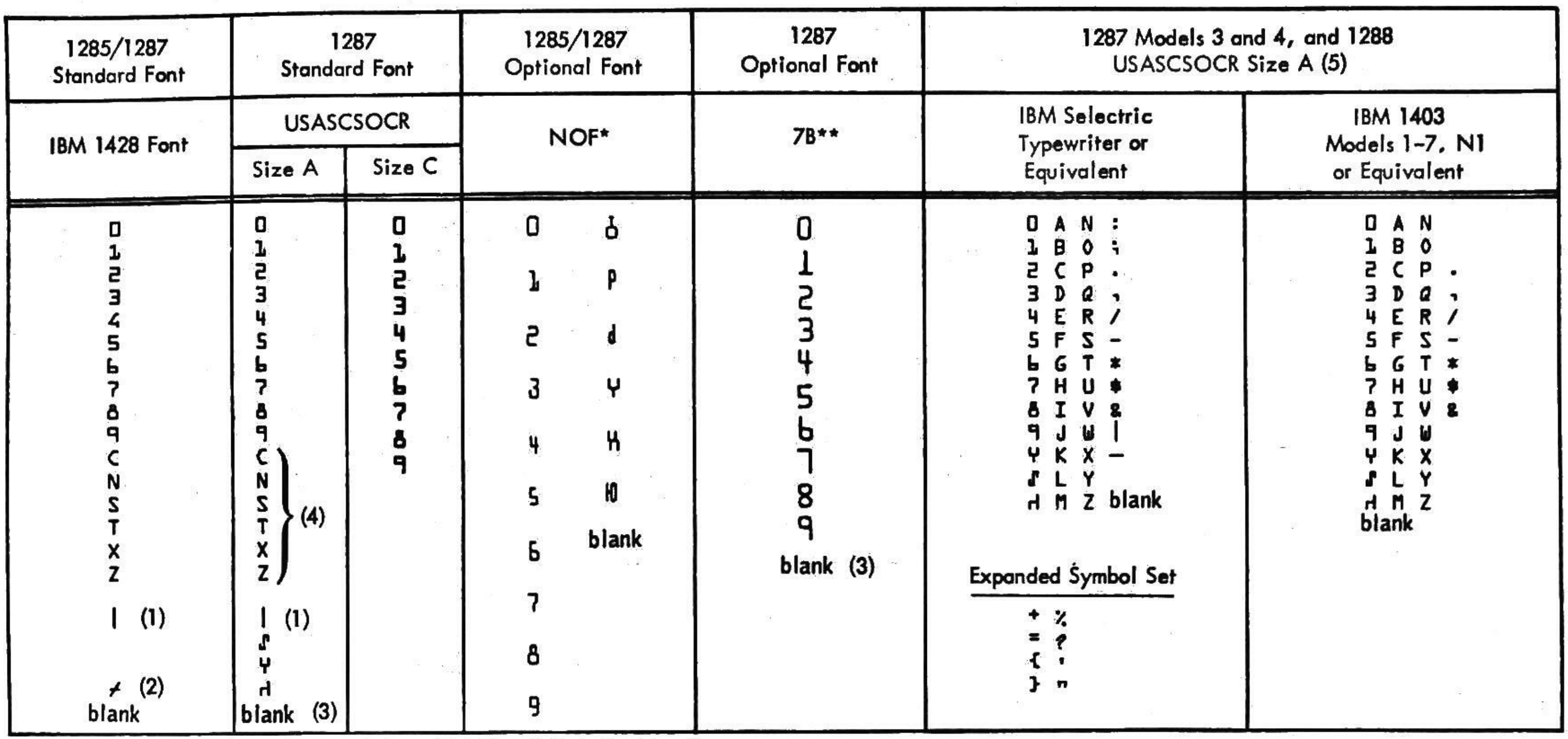
*Trademark of the Farrington Manufacturing Company



1285/1287 Standard Font	1287 Standard Font		1285/1287 Optional Font	1287 Optional Font	1287 Models 3 and 4, and 1288 USASCSOCR Size A (5)	
IBM 1428 Font	USASCSOCR Size A	USASCSOCR Size C	NOF*	7B**	IBM Selectric Typewriter or Equivalent	IBM 1403 Models 1-7, N1 or Equivalent
0 1 2 3 4 5 6 7 8 9 C N S T X Z | (1) ⌿ (2) blank	0 1 2 3 4 5 6 7 8 9 C (4) N (4) S (4) T (4) X (4) Z (4) | (1) ⑀ ⑂ ⑁ blank (3)	0 1 2 3 4 5 6 7 8 9	0 ծ 1 P 2 d 3 Y 4 Ḣ 5 Ħ 6 blank 7 8 9	0 1 2 3 4 5 6 7 8 9 blank (3)	0 A N : 1 B O ; 2 C P . 3 D Q , 4 E R / 5 F S - 6 G T * 7 H U $ 8 I V & 9 J W | ⑂ K X — ⑀ L Y ⑁ M Z blank Expanded Symbol Set + % = ? { ' } "	0 A N 1 B O 2 C P . 3 D Q , 4 E R / 5 F S - 6 G T * 7 H U $ 8 I V & 9 J W ⑂ K X ⑀ L Y ⑁ M Z blank

*NCR Optical Font shown by permission of National Cash Register Co.
**7B shown by permission of Farrington Manufacturing Co.

(1) Recognized on cut-form documents only.
(2) Recognized on journal rolls only.
(3) No blanks are transmitted in either USASCSOCR Size C or Farrington 7B font.
(4) In USASCSOCR Size A font, the characters C, N, S, T, X, and Z are available for use on journal rolls only.
(5) USASCSOCR Size A is usable only on cut-form documents on the 1287 Model 4.

NOTE: Characters and symbols are shown reduced in size.

Figure 7-36. Characters and Symbols Acceptable by the IBM 1285, 1287, or 1288

is not suitable for reading by the machine. The feature uses a ten-position numbering head. The first five numbers are for repetitive printing of items (such as dates and batch number); the other five numbers may be set either to repeat a given set of numbers or to number sequentially. Documents smaller than 3 inches wide by 4.75 inches long cannot be processed by machines having this feature. The operator controls which documents will be numbered.

Model Differences: Model 1 can read documents having as many as 24 lines of printed numeric data from each document, each line having as many as 88 characters.

Model 2 performs the same functions as Model 1, and in addition can read 38 numeric characters per line from continuous rolls of paper, such as cash-register or adding-machine tapes. The Model 2 is designed for easy changeover from documents to journal rolls (or vice versa) in seconds. In journal roll reading, the rolls are threaded automatically, and the operator can control the fields to be scanned by setting a dial.

Models 3 and 4 differ from Models 1 and 2 in that they have the added capability of reading the alphameric USASCSOCR-A font produced by a SELECTRIC® typewriter or an IBM 1403 Printer.

Document Flow: The input hopper of the 1287 can hold a 12-inch stack of documents, and the three output stackers can each hold 4 inches of documents. Each document is fed to the read station; from there the program sends it to one of the three output stackers, one of which is normally reserved for documents containing unrecognizable characters. The machine can be adjusted to overflow automatically between the other two stackers to extend the length of document runs without stopping to remove or adjust the stacker contents. All documents are automatically counted.

1288 Optical Page Reader Model 1

The IBM 1288 Optical Page Reader (Figure 7-35) reads data from cut-form documents that range in size from 3 by 6.5 inches to 9 by 14 inches. Because the 1288 can read mixed data from documents smaller than punched cards and as large as legal-size forms, it can be used in a variety of applications in government, business, and industry.

Rates of Processing Data (Throughput): The speed of document processing depends primarily on the size of each document, the format (if any), and the organization of the processing program, and is calculated from formulas which take these factors into consideration. Typical throughputs are approximately 328 forms per minute for punched cards with 12 characters on each of two lines, and approximately 14 per minute for 8½- by 11-inch (letter-size) documents with 65 characters on each of 50 lines.

Character Recognition: The 1288, like the 1287, reads symbols and alphameric characters compatible with the USASCSOCR-A and ISO OCR-A Size 1 fonts. The machine's reading capability may be expanded with special features, such as the numeric handwriting feature, the optical mark reading feature, and the expanded symbol set, all described previously for the 1287.

Whenever the 1288 encounters a hand-printed character that it does not recognize, it automatically rescans the character. If the character remains unreadable, then the 1288 transmits a substitute character to the central processing unit and ejects the document (under program control) into one of two stacker pockets for off-line correction.

Serial Numbering: This feature, described previously for the 1287, is also available with the 1288. The smallest document that can be numbered on a 1288 with this feature is 3 by 6½ inches, the minimum document size handled by the 1288.

Format Flexibility: The 1288 can process both formatted and unformatted documents. In formatted mode, under program control, the 1288 reads fixed- and variable-length fields in any sequence. In unformatted mode, however, the machine reads multiple and continuous variable-length lines of alphameric data, up to six lines per inch, right- or left-justified.

Document Flow: The input hopper of the 1288 can hold a 10-inch stack of documents, and the two output stackers can hold either a 4½-inch stack of short documents or a 3-inch stack of long documents. Each document, after being read, is sent (under program control) to one of the two output stackers, one of which is normally reserved for documents containing unrecognizable characters.

1418 Optical Character Reader Models 1-3; 1428 Alphameric Optical Reader Models 1-3

Like other optical and magnetic character readers previously described, the IBM 1418 Optical Character Reader (Figure 7-37 or IBM 1428 Alphameric Optical Reader (Figure 7-38) can read data directly from a source document, thus removing the necessity of transcribing its data for entry into the system. The documents read by the 1418 or 1428 are prepared mainly by the IBM 1403 (most models) and by electric typewriters. The printing devices must be equipped with one of the type styles designated for 1418 or 1428 input.

The 1418 and 1428 differ mainly in that the 1418 reads numeric data, and the 1428 reads alphameric data.

The 1418 reads the special characters — □ and the digits 0-9. The 1428 reads the upper-case letters A-Z, the special characters $ - . , * / and the digits 0-9. Either machine reads a solid vertical line preprinted on the forms. Characters can be printed ten or fewer per inch; adjacent fields can be printed at a different pitch (number of characters per inch).

Model 1 of either machine has three stackers and can select the documents according to three classes or general categories. Model 2, with 13 stackers, can sort documents numerically in addition to sorting by class. Model 3, which is similar in appearance and operation to Model 1, handles a broader range of document sizes and thicknesses than either Model 1 or 2 and is particularly suitable for cash-accounting

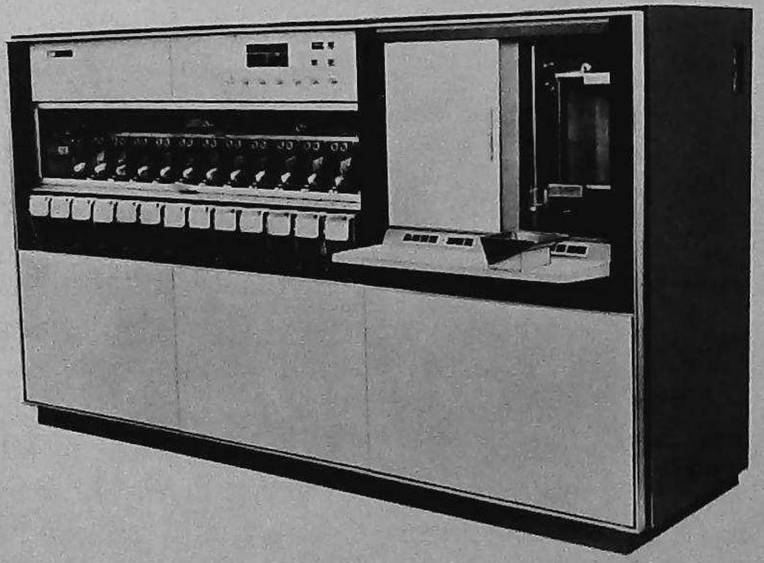


Figure 7-37. IBM 1418 Optical Character Reader

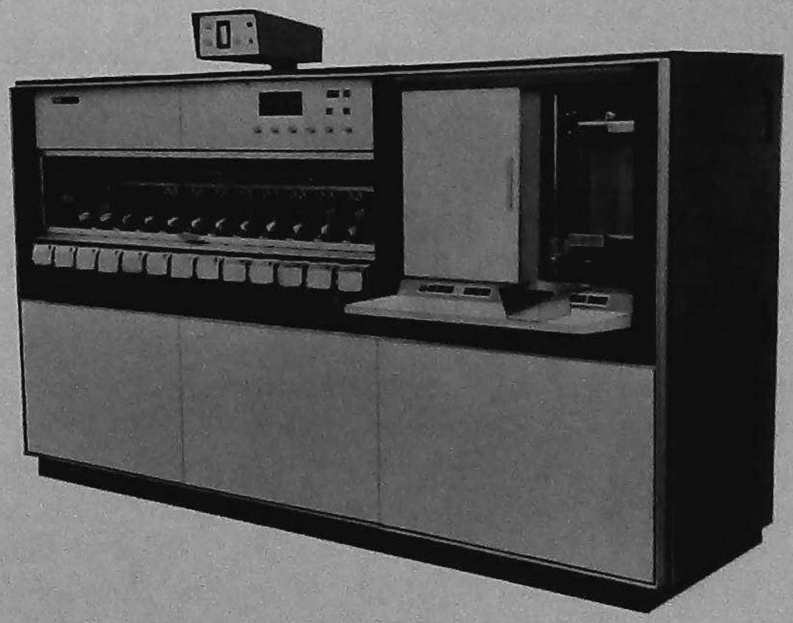


Figure 7-38. IBM 1428 Alphameric Optical Reader

applications in which a small stub is returned with a payment. All models have a 12-inch hopper, a document counter, and a character reading station.

The speed for all models, in terms of documents per minute, has the relationships to document width that are indicated in Figure 7-39.

Mark-reading special features permit reading prescribed pen or pencil marks directly into the system. In place of these, an additional read station special feature permits the reading of information from any of two lines on a document in one pass.

Only one 1418, or one 1428, may be attached per system.

	Models 1 and 2		Model 3		
	Vertical Range	Horizontal Range	Vertical Range, Nominal	Horizontal Range, Nominal	
Document Size, Inches 1418 or 1428	$2\frac{3}{4} - 3\frac{2}{3}$	$5\frac{7}{8} - 8\frac{3}{4}$	$2\frac{1}{3} - 4\frac{7}{32}$	$3 - 8\frac{3}{4}$	
				Subrange $3 - 5\frac{1}{2}$	Subrange $5\frac{7}{8} - 8\frac{3}{4}$
Speed, Documents Per Minute					
1418		420-300		420-375	420-300
1428		400-288		400-360	400-288

Figure 7-39. IBM 1418 and 1428 Document Reading Speeds

Printers

1053 Printer Models 1 and 4

The IBM 1053 Printer (Figure 7-40) is a small unit similar to the IBM 1052 Printer-Keyboard (Figure 7-30) but has the printer function only and no keyboard for entry of data. The 1053 prints at 14.8 characters per second.

The 1053 can be connected to the system in three ways, of which the first and second apply to the 1053 Model 1 and System/360 Model 30, and the third applies to the 1053 Model 4 and System/360 Models 30-91:

1. Via the IBM 1051 Control Unit Model N1, providing either:
   a. the printing function alone, installed in place of 1052 Printer-Keyboard Model 6 or 8 and operating with no other I/O devices of a 1050 system.
   b. the printing function together with (or instead of) the functions of a 1052 Printer-Keyboard Model 5 and, in addition, those of some other local I/O devices of a 1050 system. (See "1052 Printer-Keyboard Models 3, 5, 6, 7, and 8.")
2. Via the IBM 1051 Control Unit Model 1, providing the same functions (item 1a or 1b) as when connected via the 1051 Model N1; the only differences are that the 1052 used for the function under item 1b is a Model 3 and the 1051 Model 1 may also connect remote 1050 systems for off-line operations. Other 1053's may be included in the remote 1050 systems. (See "1050 Data Communication System.")
3. Via the IBM 2848 Display Control for printout in a display application. (See "2260 Display Station.")

Attachment Via 1051

When the 1053 Model 1 is attached via one of the 1051 control unit models, it has an interchangeable printing sphere and prints a maximum line length of 13 inches. Line spacing (either 6 or 8 to the inch), character spacing (either 10 or 12 to the inch), and the font of each printing sphere are as specified by the customer.

Several special features are available for a 1053 connected via a 1051; these include a forms feed that provides control over the vertical movement of continuous paper forms, and an accelerated carrier return feature for speeding the carrier return time to about half that of a standard 1053.

Attachment Via 2848

The 1053 Model 4, attachable via the 2848 display control, differs in the following ways from a 1053 Model 1:

1. The functions of the four keys for tabulation, carrier return, and spacing control are not provided.
2. Alternate printing spheres may not be specified; the character set is considered fixed.
3. The accelerated carrier return and forms feed special features are not available.
4. A power on/off key and light assembly is added.

1403 Printer Models 2, 3, 7, and N1

Four different models of the IBM 1403 Printer (Figures 7-41 and 7-42) can be attached to the System/360:

PRINTER MODEL	PRINTING POSITIONS	MAXIMUM RATED SPEED (LINES PER MINUTE)
1403-2	132	600
1403-3	132	1,100
1403-7	120	600
1403-N1	132	1,100

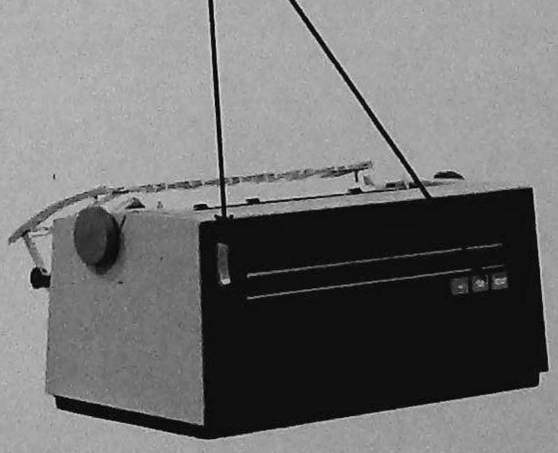


Figure 7-40. IBM 1053 Printer Model 1

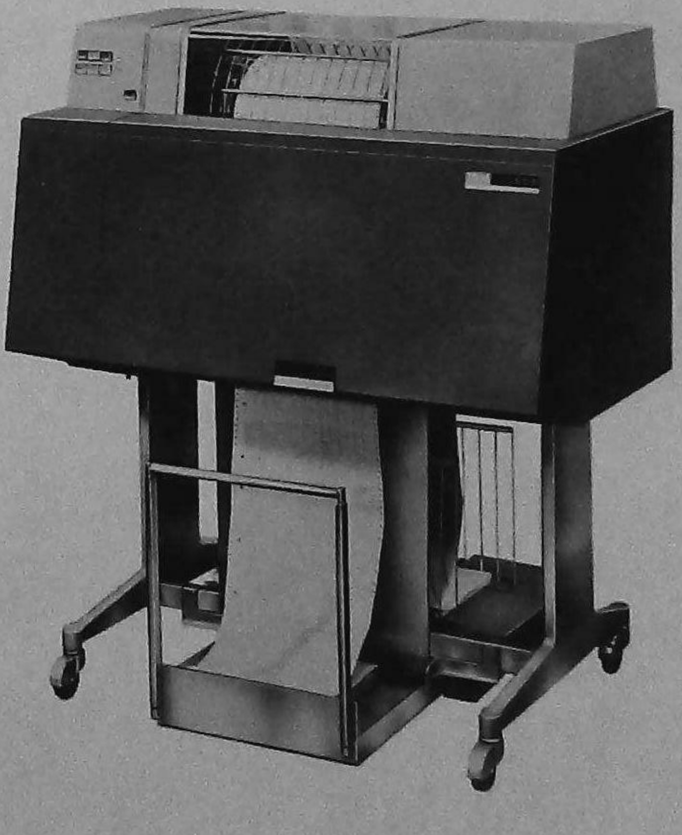
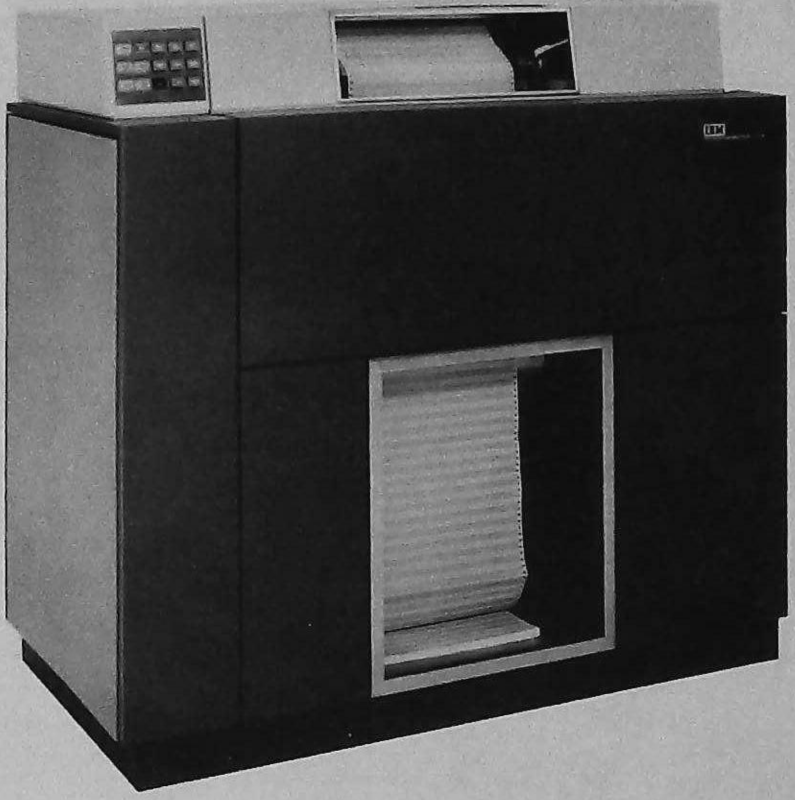


Figure 7-41. IBM 1403 Printer Models 2, 3, and 7



●Figure 7-42. IBM 1403 Printer Model N1

The Models 2, 3, and N1 can operate at still higher speeds with the universal character set feature, described later.

Any model of the 1403 Printer is controlled and buffered by the 2821 Control Unit, which also provides the attachment to a System/360 channel. One, two, or three 1403's can be controlled by each 2821, depending on the 2821 model. (See "2821 Control Unit Models 1-5.")

The 1403 Model 2 or 7 uses a chain of linked characters for printing, and the Model 3 or N1 uses a train of characters not linked together. As an optional feature, an interchangeable chain cartridge adapter is available for the Model 2 or 7. (At least one IBM 1416 Interchangeable Train Cartridge is required for each Model 3 or N1.) Either cartridge adapts the 1403 for quick and convenient changing of type fonts or character arrangements for special printing jobs.

Characters are printed ten to the inch, and lines are spaced either six or eight to the inch under operator control. An auxiliary ribbon feeding special feature adapts the Model 2 or 7 for the use of polyester ribbons, which give sharper impressions. This feature is standard on Models 3 and N1.

The 1403 Model 7 is the only attachable model that does not have a dual-speed carriage – a feature that provides high-speed skips at 75 inches per second when skipping is more than eight lines. Skipping speed on the Model 7 is 33 inches per second.

The 1403 Model N1 (Figure 7-42) differs from all other models in featuring sound-absorbent covers extending to the floor, power-operated front and top covers, and a newly designed forms cart; otherwise, it is the same as Model 3.

The selective tape listing feature and the universal character set feature are available for the 1403 Models 2, 3, and N1.

Selective Tape Listing

The selective tape listing feature provides the capability of substituting longitudinal strips for the normal paper sheet forms. Four 3.1-inch tapes, eight 1.5-inch tapes, or a combination of these less than 13.2 inches wide, may be printed. Up to 29 characters can be printed on a 3.1-inch tape, or up to 13 on a 1.5-inch tape. Each tape is individually line-spaced under program control; with no skipping permitted. Changing from tapes to standard forms, or vice versa, is easily accomplished by an operator.

A newer selective tape listing feature is available for a 1403 Model N1 used with System/360 Models 25, 30, 40, and 50. This feature permits skipping at the rate of 33 inches per second over a distance fixed by Field Engineering adjustment at a value within the range of 3 to 22 inches; this is in lieu of the repetitive line spacing required by the other version of the feature. Operation is quieter. Changeover from tape listing mode to full-sheet printing is made still easier; this and other new operator conveniences have a beneficial effect on the feature's overall efficiency.

Universal Character Set

The universal character set feature (UCS) provides the user with the ability to load from cards, into a special storage area in the IBM 2821 Control Unit, any set of discrete codes up to a maximum of 240. The codes in 2821 storage correspond specifically and sequentially with the characters on the train or chain. The user may order any characters for a given set, including custom designs for special applications.

The chain or train has 240 type positions, which, prior to UCS, were divided into five identical sets of 48 characters each. The rated maximum printing speed of a given printer is based, partially, on this division into five identical sets. If characters are included only one, two, or even four times on the chain or train, the rated maximum printing speed is necessarily reduced. The reduction, however, is not linear, because of other factors than the number of character sets (e.g. single spacing vs. skipping). Conversely, if the characters are included *more* than five times, the printing speed is increased beyond the rated maximum.

As already indicated, the 1403 Model 2 has a maximum rated speed of 600 lines per minute (lpm) when its chain contains the conventional five sets. If the installed set contains 240 different characters — the widest possible variety — printing takes place on the 1403 Model 2 at up to 140 lpm. Under the same conditions, printing takes place on the 1403 Model 3 or N1 at up to 310 lpm. The maximum printing speeds, with UCS, are controlled electronically and are 750 lpm for Model 2, and 1400 lpm for Model 3 or N1.

1404 Printer Model 2

The IBM 1404 Printer Model 2 (Figure 7-43) can print on continuous paper forms at a speed of 600 lines per minute, or it can print on cards at a maximum rate of 800 cards per minute.

In printing on continuous forms, the 1404 operates exactly like a 1403 Model 2: it has 132 printing positions, the same horizontal and vertical spacing, a dual-speed carriage, and all other 1403 Model 2 standard features. However, the auxiliary ribbon feeding, selective tape listing, and universal character set special features are not available for the 1404.

When the card feed is engaged, the 1404 accepts cards, of a variety of lengths and one or two at a time, for printing. Lengths can range from 51 columns to 160 columns (80-column card with 80-column stub). Cards from 51 to 80 columns long can also be fed side by side ("two up"); when this is done, the cards may be intermixed in any combination within the 51-80 column-length range; the 800-card per minute rate is reached by this doubled throughput.

As many as 25 lines of data can be printed on each card fed. With the optional read-compare feature, punched information (up to 30 columns) from the card itself may be printed on the card during the same pass — or used as a base for computations by the system, with the results printed on the same or any following card (depending on the program). For example, data on the card, such as a social security number, can be compared with the equivalent number in a tape record as a check before additional information from tape is printed on the card. The 30 columns of "comparable" information may be non-contiguously selected from among any of the 160 card columns.

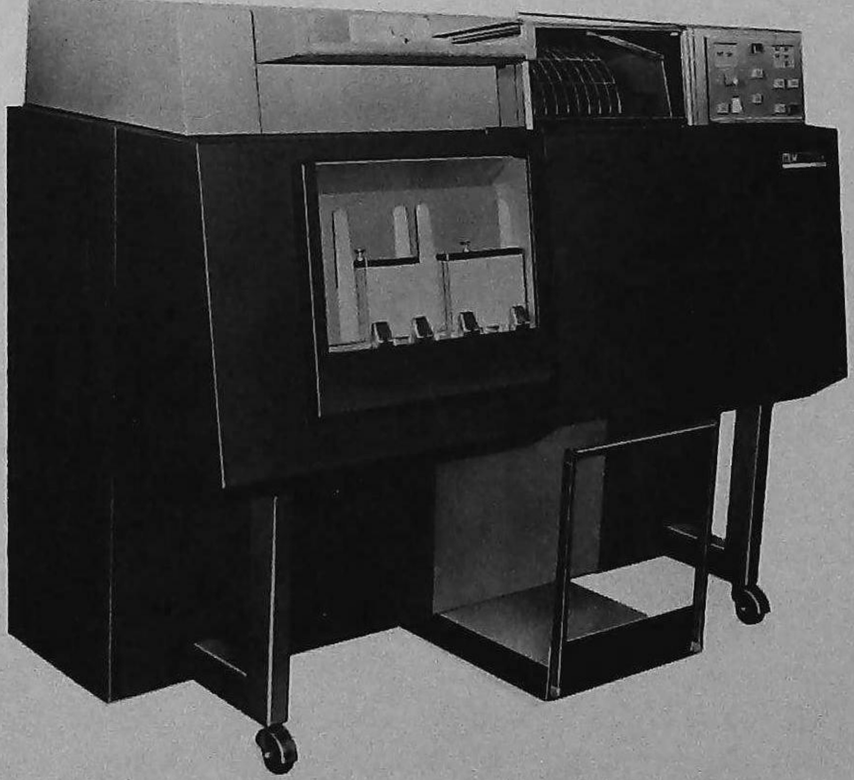


Figure 7-43. IBM 1404 Printer

The 1404 is controlled, buffered, and attached to the System/360 by an IBM 2821 Control Unit Model 4.

The 1404 uses a chain of linked characters for printing. As an optional feature, an interchangeable chain cartridge adapter is available to adapt the printer for quick and convenient changing of type fonts or character arrangements for special printing jobs.

2821 Control Unit Models 1-5

The IBM 2821 Control Unit contains the control and buffer circuitry to transmit information between the associated System/360 channel and the 2540 Card Read Punch, and/or one of the following printers: 1403 Printer Model 2, 3, 7, or N1, or 1404 Printer Model 2. Each of the five models of the 2821 provides control for a specific type and quantity of I/O:

2821 MODEL	PRINTERS		ALSO 2540 CARD READ PUNCH?	MAX UNITS CON-TROLLED
	MAX NO.	TYPE AND MODEL		
1	1	1403-2, 7, 3*, or N1*	yes	2
2	1	1403-2, 7, 3*, or N1*	no	1
3	2 (or 3*)	1403-2, 7, 3*, or N1*	no	2 (or 3*)
4	1	1404-2	yes	2
5	2 (or 3*)	1403-2, 7, 3*, or N1*	yes	3 (or 4*)

*Requires a special feature.

The buffers in the 2821 permit the transfer of accumulated data to and from the channel at a much faster rate per byte than would be possible by direct transfer to or from the attached device.

The column binary special feature can be installed on the 2821 Model 1, 4, or 5 to allow multiple punching in rows 1-7 of a card column, or reading of such multiple punches, by the 2540. This feature is *not* required to read or punch EBCDIC. (See "2540 Card Read Punch.")

On System/360 Model 67, a two-channel switch feature is available to switch the control unit (2821 Models 1-3 and 5) between two channels. An appropriate no-charge adapter is also added to the 2540 to allow independent operation of the read and punch feeds from two different channels.

1443 Printer Model N1

The IBM 1443 Printer Model N1 (Figure 7-44) prints from 200 to 600 (maximum) lines per minute, depending on the number of characters in the set being used:

13-character set — 600 lines per minute
39-character set — 300 lines per minute
52-character set — 240 lines per minute
63-character set — 200 lines per minute

The 52-character set is standard, and the other sets are available through the selective character set special feature. The user may order any characters for any set, including custom-made designs of special graphics.

The standard printed line for all sets is 120 characters long, spaced horizontally at 10 characters to the inch. Twenty-four additional printing positions are available as a special feature, raising the total number of printing positions to 144.

All characters of the print set are on a single type bar that moves back and forth across the paper. The bar is so made that each different character passes each print position. Printing takes place when the character to be printed corresponds with the character read from the printer's self-contained storage buffer.

A tape-controlled carriage, working under program control, advances paper and provides the vertical print formats. Lines are spaced six or eight to the inch under operator control. Skipping is 15 inches per second.

No external control unit is required; the control circuits and print storage buffer are within the 1443 Model N1.

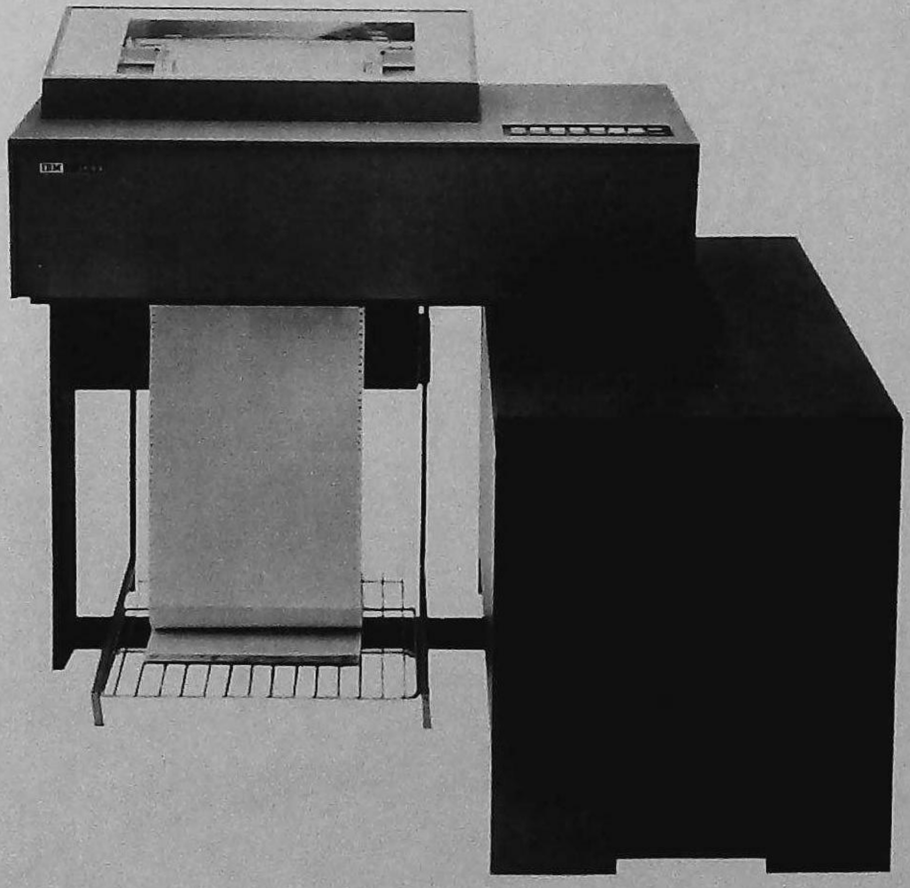


Figure 7-44. IBM 1443 Printer Model N1

1445 Printer Model N1

The IBM 1445 Printer Model N1 can print, in magnetic ink, American Banker's Association-approved type font E13B characters (Figure 7-19), as well as conventional type characters, on the same document. The magnetic ink ribbon can be replaced by the operator with a standard ribbon for conventional printing in non-magnetic ink.

All characters are printed eight to the inch (rather than the usual ten) and up to 113 characters can be printed per line. Lines are spaced six or eight to the inch under operator control. Skipping is 15 inches per second.

The standard type bar for the 1445 contains 56 characters: all 14 of the E13B characters, plus 42 alphameric and special characters. Selective character set, a special feature, adds two separate sets: a 14-character numeric set and a 42-character alphameric set. Neither of these extra sets normally includes E13B characters. Maximum printing speed is from 190 to 525 lines per minute, depending on the number of characters in the set being used:

56 characters (alphameric and E13B)	190 lines per minute
42 characters (alphameric)	240 lines per minute
14 characters (standard numeric)	525 lines per minute

The 1445 is similar in appearance to the 1443 Printer shown in Figure 7-44. Operation of the type bar and tape-controlled carriage is as described for the 1443. Like the 1443, the 1445 contains its own control circuits and storage buffer.

Punched Card Devices

1442 Card Read Punch Model N1

The IBM 1442 Card Read Punch Model N1 uses a single common card path for reading and punching, and reads and punches cards serially by card column. Serial card feeding, past a read and then a punch station, makes it possible for the program to read data from a card and then punch data (such as the results of a calculation) into the same card during a single card pass. The IBM 1442 Model N1 reads or punches cards at the following maximum rates:

Reading — 400 cards per minute
Punching — 160 card columns per second

Punching speed depends on the location of the last column punched. Interspersed blank columns between fields are considered punched columns. In terms of cards per minute, the rated speed for punching columns 1-10 is 265 cpm; for punching columns 1-80, 91 cpm.

No external control unit is required; the control circuits are within the 1442. The 1442 is not buffered.

The read hopper holds 1,200 cards. Card movement is from the hopper to the read station, to the punch station, then to one of the two stackers (pockets). The stackers hold 1,300 cards each, and cards can be removed from either stacker without stopping the machine.

The appearance of the unit is similar to that of the 1442 Model N2 shown in Figure 7-45.

Data Mode 1

In data mode 1, the 1442 Model N1 can read and punch the 256 different combinations of holes required for the extended binary coded decimal interchange code (EBCDIC). For 256 combinations, multiple punches in a single card column are required; however, no more than one punch is permitted in rows 1-7. (Rows 12, 11, 0, 8, and 9 allow 32 possible combinations, which, multiplied by the eight possibilities in rows 1-7, equal the required 256.) For multiple punches in rows 1-7, the special card image feature is required.

Data Mode 2

Operations using the card image feature are in data mode 2, which is the card image or column binary mode. The card image feature permits the low-order six bits of bytes read from the CPU to be punched alternately into the upper six and lower six rows of a card, enabling 160 such truncated bytes to be placed in the card. When reading, the information is read column by column and transmitted to the CPU byte by byte, the two high-order bits (0 and 1) set to zero.

1442 Card Punch Model N2

The IBM 1442 Card Punch Model N2 (Figure 7-45) may be connected to the System/360 to provide the card punching function only. Punching operations, speeds, internal controls, punching in data mode 2, and all other features related to punching are identical to those of the 1442 Card Read Punch Model N1, except that the 1442 Model N2 has only a single 1,300-card stacker.

2501 Card Reader Models B1 and B2

Models B1 and B2 of the IBM 2501 Card Reader (Figure 7-46) are externally identical, but the maximum card-reading rate of Model B1 is 600 per minute; of Model B2, 1,000 per minute. The Model B1 can be used for primary card input or as a console reader for the larger models of System/360. Model B2 can be used for primary card input, often with the 2520 Card Punch Model B2 for maximum card processing speeds.

No external control unit is required; the control circuits are within the 2501. The 2501 is not buffered.

Reading of cards is accomplished by photocells that convert the light passing through punched holes into electrical energy. Cards are read serially by column. The feed hopper has a 1,200-card capacity, and cards can be removed from the single 1,300-card stacker without stopping the reader.

The 2501 can read EBCDIC in standard data mode 1. For the 256 combinations in EBCDIC, multiple punches

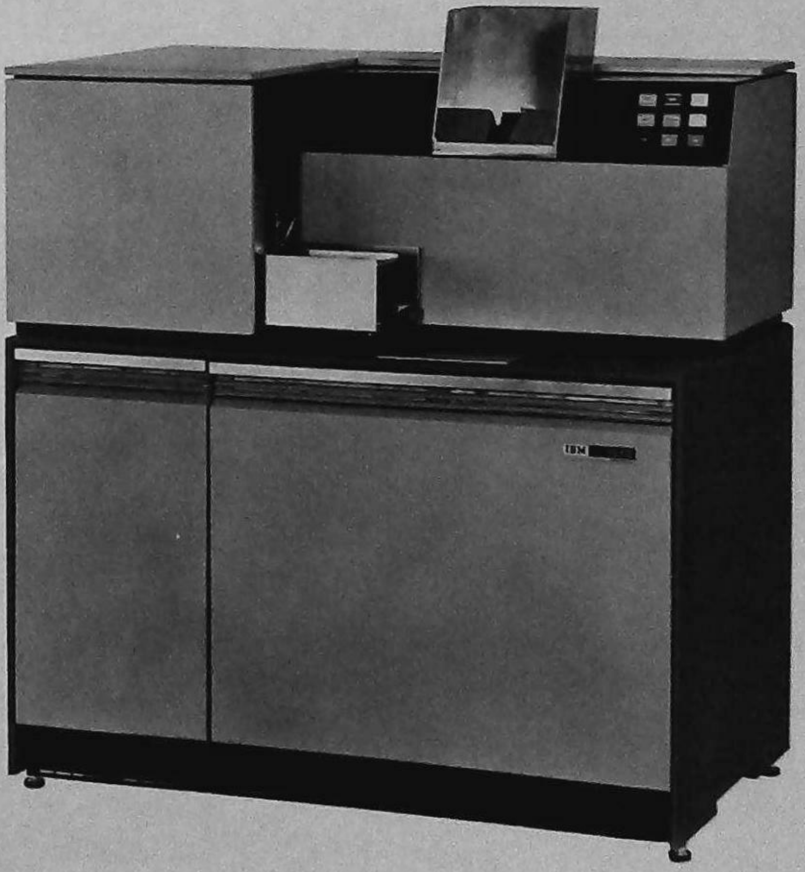


Figure 7-45. IBM 1442 Card Punch Model N2

Figure 7-46. IBM 2501 Card Reader

Figure 7-47. IBM 2520 Card Read Punch Model B1

in a single card column are required; however, no more than one punch is permitted in rows 1-7. For multiple punches in rows 1-7, the special card image feature is required. For a description of reading in card image mode, see "Data Mode 2" in the 1442-N1 description.

2520 Card Read Punch Model B1

The IBM 2520 Card Read Punch Model B1 (Figure 7-47) reads and punches cards at a maximum rate of 500 per minute. Operation of the 2520 Model B1 is the same as for the 1442-N1 or 2501 with respect to serial-by-column card reading, and is like the 1442-N1 in that:

1. The feed hopper has a 1,200-card capacity.
2. Cards can be removed from either 1,300-card stacker while the machine is running.
3. Cards are moved past a read station and then past a punch station.
4. Prepunched cards can be fed through the punching station without a special feature.

As in the 2501, cards are read by photocells that convert the light passing through punched holes into electrical energy.

The punching operation of the 2520 differs from that of the 1442; punching is parallel by row instead of serial by column. Each card is fed in parallel and read serially while the preceding card, its axis turned 90 degrees, is passing the punching station (Figure 7-48).

No external control unit is required; the control circuits are internal. The 2520 punching operations are buffered; the reading operations are not buffered.

The 2520 can read and punch EBCDIC in the standard data mode 1. For the 256 combinations in EBCDIC, multiple punches in a single card column are required; however, no more than one punch is permitted in rows 1-7. For multiple punches in rows 1-7, the special card image feature is required. For a description of reading and punching in the card image mode, see "Data Mode 2" in the 1442-N1 description.

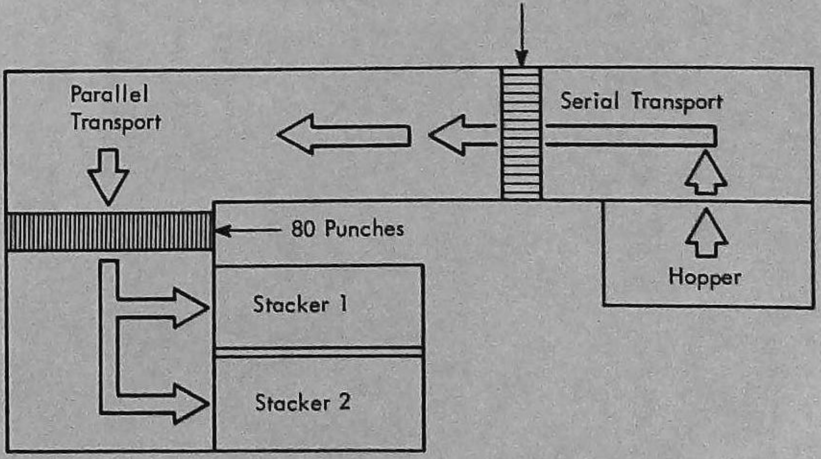


Figure 7-48. Card Path in IBM 2520 Card Read Punch Model B1

2520 Card Punch Models B2 and B3

The IBM 2520 Card Punch Model B2 or B3 may be connected to the System/360 to provide the punching function only. Models B2 and B3 are externally identical (and the same as the 2520-B1 shown in Figure 7-47), but the maximum card-punching rate of Model B2 is 500 per minute; of Model B3, 300 per minute.

Internal controls, punch buffering, punching in data mode 2, the punching speed of Model B2, and all other features related to punching are identical to those of the 2520 Card Read Punch Model B1.

2540 Card Read Punch

The IBM 2540 Card Read Punch (Figure 7-49) reads cards at a maximum rate of 1,000 per minute, and punches cards at a maximum rate of 300 per minute. The card reading and punching sections are separate entities, and reading and punching can take place simultaneously.

The read hopper, with its file feed, holds 3,100 cards. Five 1,350-card stackers are located between the read and punch ends of the 2540; three stackers can be used in reading and three in punching. The center pocket can be fed with either punched or read cards, but should be reserved to one or the other during a run. Cards can be removed from any pocket without stopping the machine.

The 2540 is controlled, buffered, and attached to the channel by a control unit (see "2821 Control Unit Models 1-5").

An optional 51-column interchangeable read feed feature permits feeding either 51-column cards or standard 80-column cards in the read feed of the machine. The 51 columns correspond to columns 15-65 of an 80-column card. (Fifty-one column cards may be postal money orders, installment payments, inventory cards: for example, a detached 51-column stub from an 80-column card.) Installation of this feature permanently reduces the maximum card-reading speed to 800 cards per minute. The first two read pockets are modified so that the operator can adjust for either 80- or 51- column operation. During the time that the pockets are set for 51-column cards, the capacity of the two pockets is reduced to 800 cards each and longer cards cannot be fed.

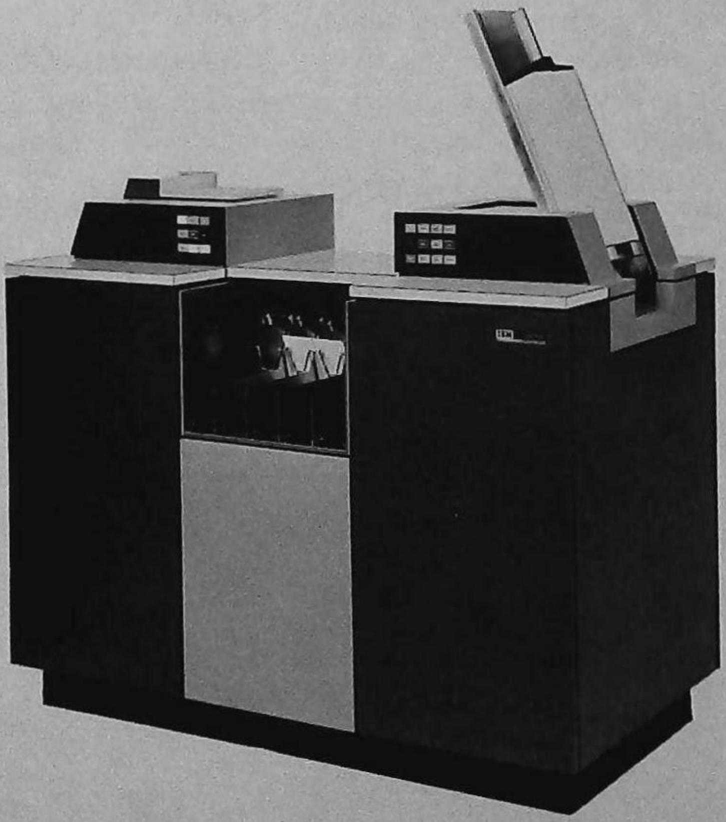


Figure 7-49. IBM 2540 Card Read Punch

An optional punch feed read feature enables the 2540 to punch output data into the same card from which input data was read. (Column binary cards cannot be read in the punch feed.) Unless this feature is installed, only blank cards can be fed through the punching section.

The 2540 can read and punch EBCDIC. For the 256 combinations in EBCDIC, multiple punches in a single card column are required; however, no more than one punch is permitted in rows 1-7. For multiple reading or multiple punches in rows 1-7, the column binary special feature must be installed on the 2821. Column binary cards are read or punched exactly as described under "Data Mode 2" in the 1442-N1 description.

2560 Multi-function Card Machine Model A1

The IBM 2560 Multi-function Card Machine Model A1, which attaches to a System/360 Model 25 in Model 20 Mode only (Figure 7-50), provides the combined functions of a card reader, a card punch, a collator, and, with an optional feature, a card interpreter/document printer in one unit.

The 2560-A1 has two card hoppers, a read station, a punch station, an optional printing station, and five radial stackers. Thus, it offers full card-file maintenance facilities plus the capabilities of two, four, or six lines of card document printing.

Cards from either the primary or secondary hopper can be read, punched, and fed into any one of the stackers. The traditional unit record functions of reproducing, gangpunching, summary punching, collating, selecting, and sorting can be performed on the 2560-A1 under program control. With the card print feature installed, the capabilities of the 2560-A1 are expanded to include those of an interpreter and a card document printer.

Card Reading

The 2560-A1 reads cards serially at 500 cards per minute. As each card moves through the read station, it is scanned, column by column, by photosensing ele-

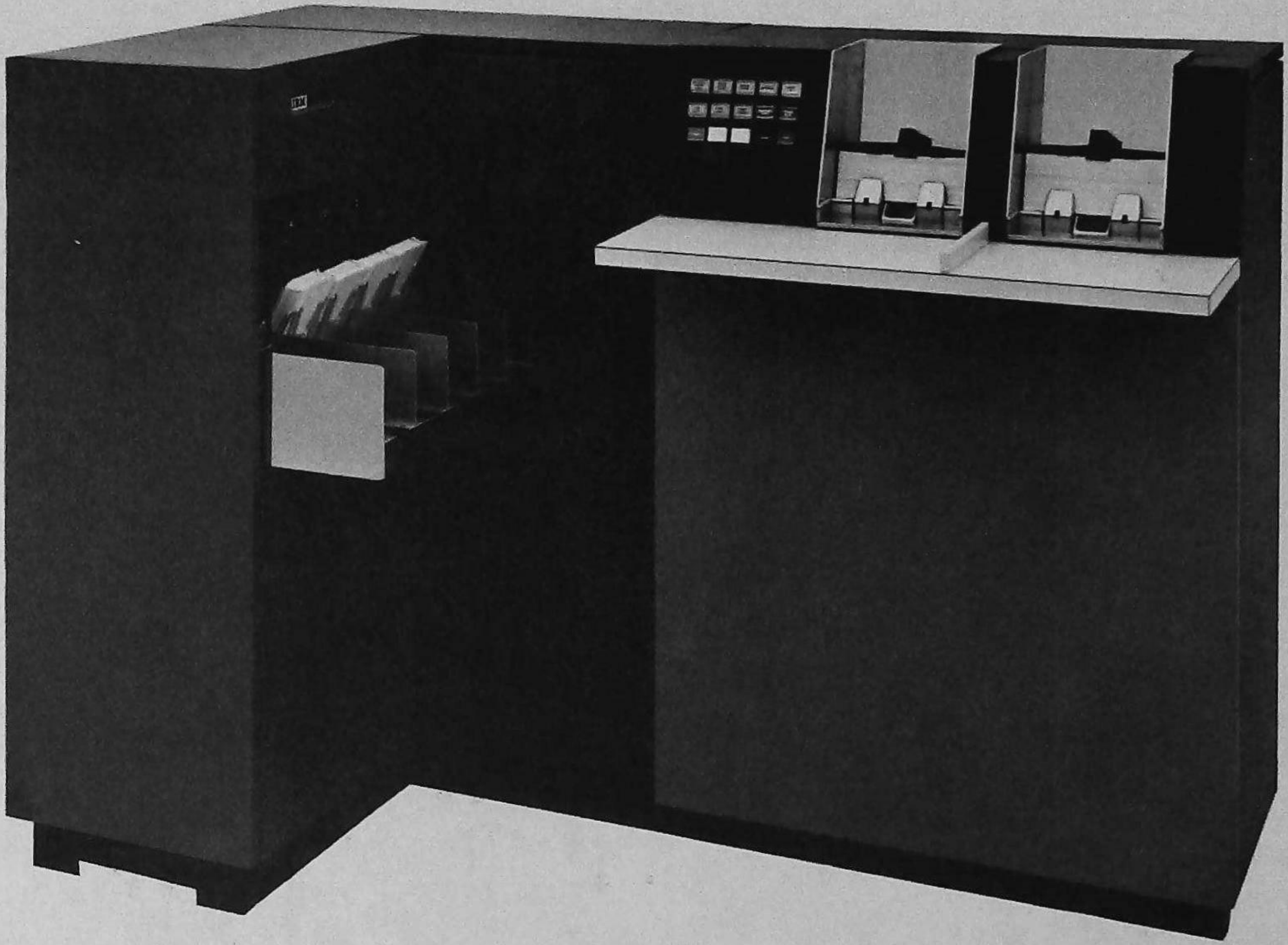


Figure 7-50. IBM 2560 Multi-function Card Machine Model A1

ments. While in the read station, the card is checked for validity of data, off-register punching, and proper alignment.

Card Punching

The card advances to the prepunch station and then through the punch station under program control. As the card is punched, the punch-data is transmitted to the CPU for verification by the program.

Cards are punched at 160 columns per second. The total time required for punching depends on the last column punched. For example, 2560-A1 output rates vary from 91 cards per minute, when column 80 is the last column punched, to 260 cards per minute, when punching stops at column 10.

Card Document Printing

The card print feature, if installed, is located just beyond the punch station in the card path. Two, four, or six printing heads can be installed to print serially as the card moves through the print station. Each printing head can be manually adjusted to print in any one of 25 line positions not occupied by another head. Line positions are: above the 12-punch position, on each row of punch positions, between the rows of punch positions, and below the 9-punch position.

Each printing head can print 62 different characters, plus the character blank, as transmitted from main storage. Character spacing is ten to the inch, and each line can be 64 characters long. Printing extends from approximately column 2 to column 75.

Printing speed is 140 character-columns per second, regardless of the number of lines printed. Six hundred 64-character lines per minute (100 cards per minute) can be printed if six lines are printed on each card; this time includes card movement and registration. Printing time is reduced correspondingly as the number of character-columns is reduced.

Figure 7-51 summarizes the essential characteristics of all card equipment discussed.

Card Unit	Read Speed (Cards Per Min)	Punch Speed	Read and Punch Same Card?	Self-Contained Control Unit?	Buffers
1442-N1	400	160 card col per sec †	yes	yes	none
1442-N2	---	160 card col per sec †	---	yes	none
2501-B1	600	-------------------	---	yes	none
2501-B2	1,000	-------------------	---	yes	none
2520-B1	500	500 cards per minute	yes	yes	punch
2520-B2	---	500 cards per minute	---	yes	punch
2520-B3	---	300 cards per minute	---	yes	punch
2540	1,000*	300 cards per minute	yes	no	read and punch
2560	500	160 card col per sec †	yes	yes	none

* 800 if 51-column interchangeable read feed feature is installed.

† 265 cards per minute punching columns 1-10; 91 cards per minute punching all 80 columns.

Figure 7-51. Basic Comparison of Card Equipment for System/360

Punched Tape Devices

1017 Paper Tape Reader Models 1 and 2; 1018 Paper Tape Punch; 2826 Paper Tape Control Unit Model 1

The IBM 1017 Paper Tape Reader (Figure 7-52) reads 5-, 6-, 7-, and 8-track paper tape and laminated polyester tape at a rate of up to 120 characters per second. Tape width is 11/16 inch for 5-track telegraphic code, 7/8 inch for 6- and 7-track codes (including 6-track advanced feed hole and Japanese format), and 1 inch for 8-track codes. Reading and backspacing is program-controlled on a character-by-character basis. Bit configurations transmitted correspond directly with character hole patterns read. Any code translation must be performed by the program after characters have been read into main storage. Parity checking (odd, even, or none) is determined by a switch on the operator panel.

The 1017 Model 1 reads strips of tape only. The Model 2 is equipped with a reeler, for reading both tape strips and reeled tape.

The IBM 1018 Paper Tape Punch (Figure 7-53) punches 5-, 6-, 7-, and 8-track paper tapes and most laminated polyester tapes at a speed of up to 120 characters per second. Tape width is 11/16 inch, 7/8 inch, or 1 inch. Three punching options are available:

Standard punching (5-, 6-, 7-, or 8-track)
Advanced feed hole punching (6-track)
Japanese tape punching (6-track)

Punching is program-controlled on a character-by-character basis. Character hole patterns punched correspond directly to bit configurations transmitted. Any code translation must be done by programming before characters are transferred for punching. Backspacing capability is available as a part of the error correction special feature and is program-controlled. The standard 1018 punches strips of tape from a supply roll on top of the machine. The take-up mechanism (special feature) allows winding of tape on a take-up reel on top of the supply reel.

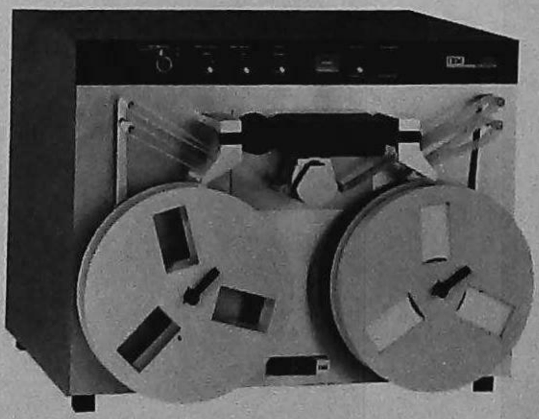


Figure 7-52. IBM 1017 Paper Tape Reader

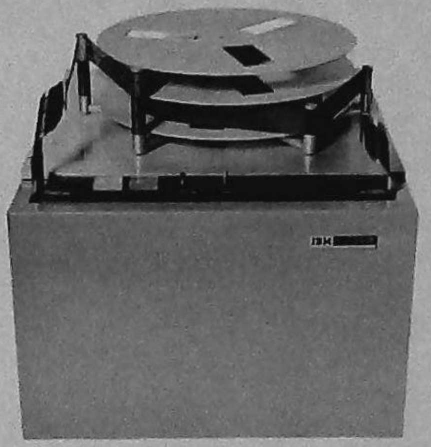


Figure 7-53. IBM 1018 Paper Tape Punch

The 1017 and the 1018 can be attached to the 2826 Paper Tape Control Unit (Figure 7-54). The 2826 attaches to the multiplexer channel of System/360. Input records can be separated by an end-of-record (EOR) character. Any character not used for other purposes can serve as an EOR character. The character to be recognized during read operations as the EOR character is determined by the setting of eight toggle switches on the 2826 control panel.

The 2826 can control as many as two readers and two punches, all of which can operate simultaneously.

Figure 7-54. IBM 2826 Paper Tape Control Unit

Maximum cable length between the 2826 and the attached punches is 350 feet. For a 1018 equipped with the error correction feature, however, the maximum cable length is 25 feet. The punch checking feature on the 2826 (a special feature), in conjunction with the 1018's error correction feature, enables the recognition and correction of parity discrepancies during punching operations.

2671 Paper Tape Reader; 2822 Paper Tape Reader Control

The IBM 2671 Paper Tape Reader (Figure 7-55) photoelectrically reads strips of 5-, 6-, 7-, or 8-channel paper tape at a rate of up to 1,000 characters per second. Tape width is 11/16 inch (for 5-track telegraphic code), ⅞ inch (6- and 7-track codes), or 1 inch (8-track codes). Tape code translation is under program control.

Various switches on the 2671 provide operator convenience and program efficiency. Examples are: end-of-record indications, parity checking (odd, even, or none), track suppression, and transmission or nontransmission to the CPU of the indications of deleted positions on tape.

The paper tape reader and the 2822 Paper Tape Reader Control (Figure 7-55) are normally attached to System/360 through the multiplexer channel, but may be attached to another channel on some models (Figure 7-1).

The basic 2671 reads strips of paper tape from 9 inches to 20 feet in length, including a 6-inch leader and 3-inch trailer. Spooling facilities are optional. With the supply option feature, 10½-inch reels of paper tape can be fed (from the outside of the reel). If the optional center roll feeding feature is added, tape can also be fed from the center of 10½-inch rolls. With the take-up option feature, the tape can be rewound on 10½-inch reels.

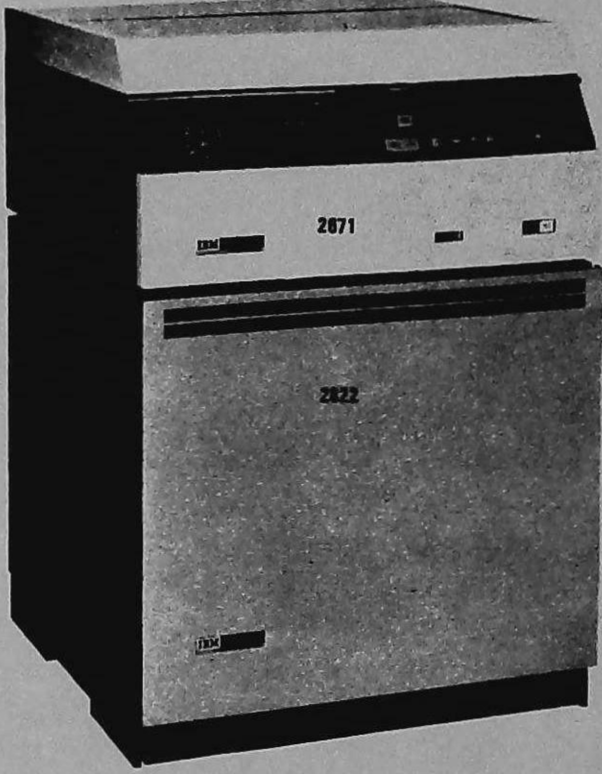


Figure 7-55. IBM 2671 Paper Tape Reader and 2822 Paper Tape Reader Control

After acceleration time (about 8 milliseconds), the data rate reaches 1,000 characters per second for strips. With the spooling facilities, the data rate varies between 500 and 1,000 characters per second, depending on the length of a record.

The 2671 is especially designed for data communications, source recording, scientific data processing, and data acquisition.

Section 8. Teleprocessing, Data Acquisition, and Process Control Systems and Devices

The following systems and devices are attachable online to System/360. Most are attachable through the 2701 Data Adapter Unit, the 2702 or 2703 Transmission Control, or the 3705 Communications Controller. The possible connections to the various channels on the System/360 models are listed in Figure 8-1. For more information, see *IBM Teleprocessing System Summary*, GA24-3090, which contains brief descriptions of all IBM teleprocessing terminals, and *IBM SRL Bibliography Supplement–Teleprocessing and Data Collection*, GA24-3089, which contains a list of the pertinent IBM publications.

Transmission Control Devices

2701 Data Adapter Unit†
2702 Transmission Control†
2703 Transmission Control†
3705 Communications Controller†

Modulator/Demodulator Units

2711 Line Adapter Unit
3872 Modem
3875 Modem
4872 Modem Models 1, 2, and 3

Keyboard and Terminal Devices

1001 Data Transmission Terminal
1013 Card Transmission Terminal
1092 Programmed Keyboard Models 1 and 2
1093 Programmed Keyboard Models 1 and 2
2740 Communication Terminal Models 1 and 2
2741 Communication Terminal
2760 Optical Image Unit (via 2740-1)
2780 Data Transmission Terminal Models 1-4

Display Devices

2260 Display Station Models 1 and 2
2265 Display Station
2845 Display Control
2848 Display Control Models 1, 2, and 3
3271 Control Unit Models 1 and 2
3275 Display Station Models 1 and 2
3277 Display Station Models 1 and 2

Audio Communications Devices

7770 Audio Response Unit Model 3†
7772 Audio Response Unit Model 3†

Data Acquisition and Process Control Systems

1070 Process Communication System
1800 Data Acquisition and Control System

Systems

1030 Data Collection System
1050 Data Communication System
1060 Data Communication System
1130 Computing System
2770 Data Communication System
2790 Data Communication System
3270 Information Display System
3670 Brokerage Communication System
System/3 Models 6 and 10
System/7
System/360 Models 20-195
System/370 Models 135-195

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† A unit locally attached to a System/360 CPU, used to attach various terminals to System/360.

Terminal No.	Terminal Models	Terminal Name	Remote Attaching Unit	Local Attaching Unit †	22	25	30	40	44	50	65	67	75	195
1001	1	Data Transmission Terminal	–	7770	m	m	m	m	–	m	m	–	m	m
				7772	m	m	m	m	–	m	m	–	m	–
1013*	1	Card Transmission Terminal	–	2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
1030	–	Data Collection System	1031#											
				2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
1050	–	Data Communication	1051#	2702	m	m	m	m	m	m	m	m	m	m
		System		2703	m	m	m	m	–	m	m	m	m	m
				3705	–	–	m	m	–	m	m	m	m	m
				→	–	i	–	–	–	–	–	–	–	–
1060	–	Data Communication	1061#											
		System												
				2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
1070	–	Process Communication	1071#	2702	m	m	m	m	m	m	m	m	m	m
		System		2703	m	m	m	m	–	m	m	m	m	m
1092	1, 2	Programmed Keyboard	–	7770	m	m	m	m	–	m	m	–	m	m
1093	1, 2	Programmed Keyboard	–	7772	m	m	m	m	–	m	m	–	m	–
1130	–	Computing System	1131#	2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
1800	–	Data Acquisition and	Communication	2703	m	m	m	m	–	m	m	m	m	m
		Control System	Adapter	3705	–	–	m	m	–	m	m	m	m	m
				→	–	i	–	–	–	–	–	–	–	–
2260	1	Display Station	2848-3	2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
	2	Display Station	2848-1, -2	3705	–	–	m	m	–	m	m	m	m	m
2265	1	Display Station	2845	→	–	i	–	–	–	–	–	–	–	–
2721*	1	Portable Audio Terminal	–	7770	m	m	m	m	–	m	m	–	m	m
2740	1, 2	Communication Terminal	–	2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
2741	1	Communication Terminal	–	2702	m	m	m	m	m	m	m	m	m	m
2760	1	Optical Image Unit	2740-1	2703	m	m	m	m	–	m	m	m	m	m
				3705	–	–	m	m	–	m	m	m	m	m
2770	–	Data Communication	2772#	→	–	i	–	–	–	–	–	–	–	–
		System												
2780	1-4	Data Transmission	–	2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
		Terminal		2703	m	m	m	m	–	m	m	m	m	m
2790	–	Data Communication	2715-2#	3705	–	–	m	m	–	m	m	m	m	m
		System		→	–	i	–	–	–	–	–	–	–	–
3270	–	Information Display System	3271-1, -2#											
3275	1, 2	Display Station	–											
3277	1, 2	Display Station	3271-1, -2											
3670	–	Brokerage Communication	3671-1#	2701	–	–	–	–	–	ms	msx	ms	msx	bmsx
		System		2703, 3705	–	–	–	–	–	m	m	m	m	m
3735	1	Programmable Buffered Terminal	–	2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
3780	1	Data Communications Terminal	–	2703	m	m	m	m	–	m	m	m	m	m
–	6	System/3	5406#	3705	–	–	m	m	–	m	m	m	m	m
–	10	System/3	5410#	→	–	i	–	–	–	–	–	–	–	–
				2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
–	–	System/7	5010#	2702	m	m	m	m	m	m	m	m	m	m
				2703	m	m	m	m	–	m	m	m	m	m
				3705	–	–	m	m	–	m	m	m	m	m
–	20	System/360	–	→	–	i	–	–	–	–	–	–	–	–
–	25	System/360	2701, 2703, 3705, i	2701	m	m	ms	ms	mh	ms	msx	ms	msx	bmsx
–	22-195	System/360	2701, 2703, 3705	2703	m	m	m	m	–	m	m	m	m	m
–	135	System/370	2701, 2703, 3705, i	3705	–	–	m	m	–	m	m	m	m	m
–	145-195	System/370	2701, 2703, 3705	→	–	i	–	–	–	–	–	–	–	–

Symbols

Symbol	Meaning
i	Integrated communications adapter.
b	Block multiplexer channel (housed within a 2880 Block Multiplexer Channel for Model 195).
m	Byte multiplexer channel (housed within a 2870 Multiplexer Channel for Models 65-195).
s	Selector channel (housed within a 2860 Selector Channel for Models 65-195).
x	Selector subchannel (special feature for 2870 Multiplexer Channel).
→	See the information in the "Local System/360 Model" columns.
h	High-speed multiplexer channel (Model 44 only).
–	Not applicable.
*	May not be available.
#	Part of the remote system.
†	The local attaching units are: 2701 Data Adapter Unit 2702 or 2703 Transmission Control 3705 Communications Controller 7770 Audio Response Unit Model 3 7772 Audio Response Unit Model 3

Figure 8-1. Attachment Data for Teleprocessing, Data Acquisition, and Process Control Terminals

Transmission Control Devices

Just as local cable-connected input/output devices require a control unit to interface their attachment to the system channels, devices that transmit over communications lines also require a control unit to perform interface matching, character assembly, and transmission control. In System/360 teleprocessing configurations, these functions are usually performed by the IBM 2701 Data Adapter Unit, the IBM 2702 Transmission Control, and the IBM 2703 Transmission Control.

2701 Data Adapter Unit

The IBM 2701 Data Adapter Unit (Figure 8-2) provides for the on-line connection to System/360 of a variety of local and remote systems and devices. The connection can occur over private or common-carrier communications facilities (Figure 8-3).

Eight 2701's can be attached to a System/360 channel, each occupying one control unit position. With the second channel interface special feature, the 2701 can be attached to any other channel on the same CPU or to a channel on another CPU. This means that different terminal devices on the 2701 can operate via separate channels. However, the assignment of terminals to channels is permanent; once a terminal is assigned to a particular channel, it can operate only via that channel.

Each 2701 provides for the attachment of up to four half-duplex (two ways alternately) asynchronous communications lines with line speeds up to 600 bits per second, or up to four (maximum of two operating simultaneously) half-duplex synchronous communications lines with line speeds up to 40,800 bits per second, or up to four parallel data acquisition devices (word width of 16 to 48 bits). Various combinations of the data communications and data acquisition devices are possible within any given 2701.

All necessary bit-byte and word-byte conversions, interface matching, and data control for attaching specific terminal devices is accomplished by the functional sections of the 2701. Many optional features are available for further refinement in meeting user requirements.

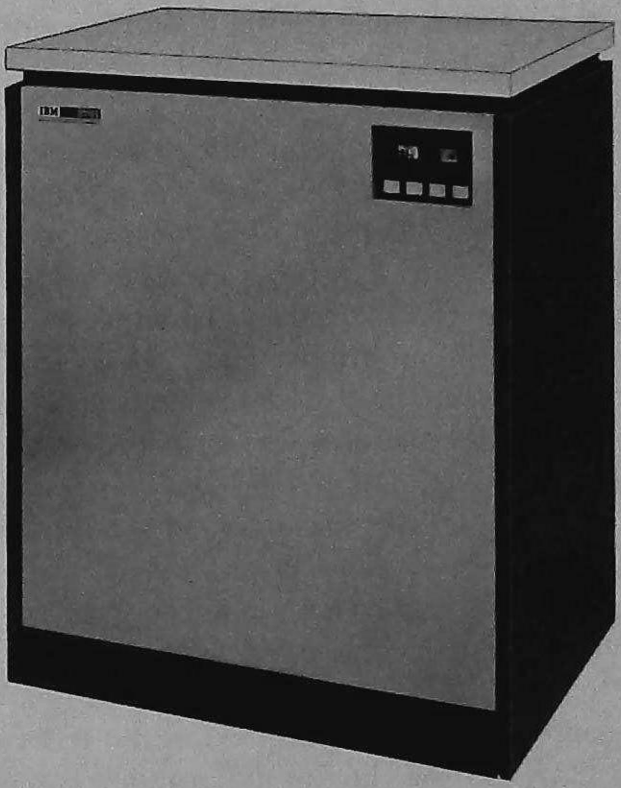


Figure 8-2. IBM 2701 Data Adapter Unit

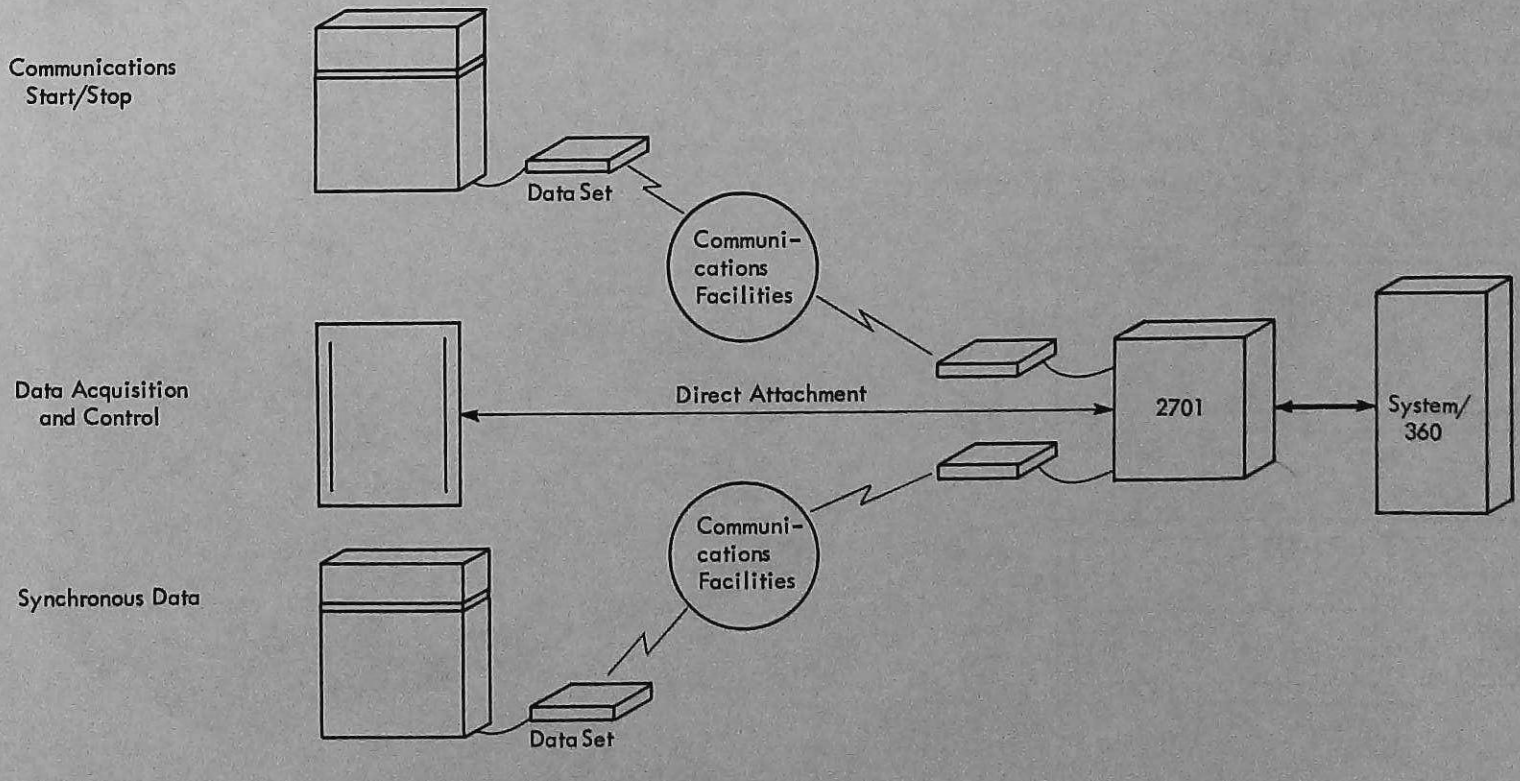

Communications Start/Stop
Data Set
Communi-cations Facilities
Data Acquisition and Control
Direct Attachment
2701
System/360
Communi-cations Facilities
Synchronous Data
Data Set

Figure 8-3. 2701 in a System Environment

Functional Sections

The basic IBM 2701 Data Adapter Unit consists of two functional sections: the transmission interface converter (XIC), and the transmission adapter (XA). See Figure 8-4. The XIC and XA operate as a couple which provides a single complete path for the operation of the terminal devices with the channel. The transmission interface converter is the same for all 2701's, but the transmission adapter in one 2701 may differ from that in another 2701. Different transmission adapters must be chosen to accommodate different types of terminals.

Although the basic 2701 allows for only one XIC-XA couple, three more may be obtained through the 2701's special features.

Transmission Interface Converter (XIC): The transmission interface converter controls information transfer between a System/360 channel and a transmission adapter of a 2701. When the 2701 is connected to the selector channel, byte transfer is in burst mode; when it is connected to the multiplexer channel, byte transfer is normally in multiplex mode. However, when operating with the multiplexer channel, a manual switch can be set to force burst mode or to allow multiplex mode. In multiplex mode, an XA causes single- or multiple-byte transfers, depending on the type of XA.

Transmission Adapter (XA): The transmission adapter provides for the connection of remote and local devices to the 2701. It contains the circuitry and logic for the control of the terminal device, the buffering of the data flow, the decoding of the program commands, and the connection to and operation with the XIC and the I/O channel.

Three classifications of the transmission adapter are used with the 2701: communications-start/stop, communications-synchronous, and data acquisition and control (parallel data adapter). The adapters in each classification operate with terminals that transmit in one of the three modes described under "Transmission Modes."

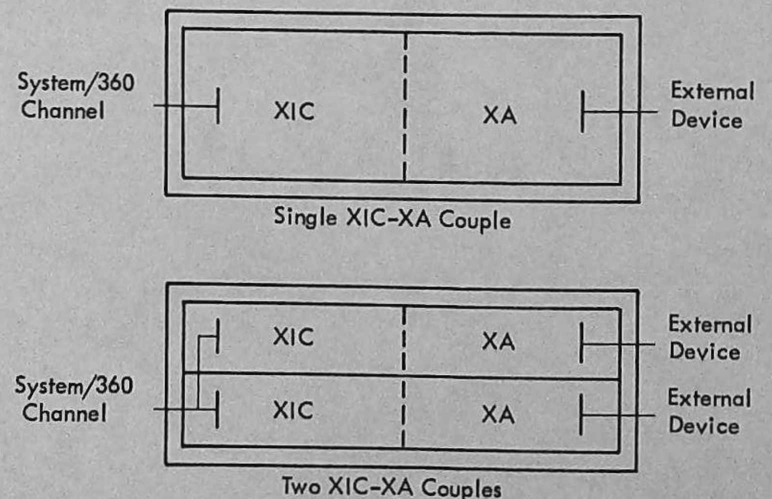


Figure 8-4. 2701 Functional Sections

Special Features

The expansion feature and the expanded capability feature allow the expansion of the basic 2701 (one XIC-XA couple) to as many as four couples. A variety of other features is also available. The *Data Communications and Acquisition Configurator,* Form A22-6824, shows the various features for the 2701 and diagrams the numerous configurations possible with this unit.

2702 Transmission Control

The IBM 2702 Transmission Control (Figure 8-5) performs functions similar to those of the 2701 Data Adapter Unit. The 2702 Transmission Control provides for the on-line attachment to System/360 of various asynchronous systems and I/O devices via private or common-carrier transmission facilities.

The 2702 Transmission Control occupies one control unit position on a System/360 multiplexer channel. As many as eight 2702's can be attached to any multiplexer channel, and the operation of each is in multiplex mode. Every attached communications line requires one subchannel.

The 2702 is a modular unit with a variety of features to meet a customer's data communications needs. It is flexible in line capacity, transmission code, and speed. The basic 2702 can have 15 half-duplex lines and operate at speeds up to 180 bits per second for any and all attached communications lines. All lines can oper-

Figure 8-5. IBM 2702 Transmission Control

ate simultaneously. With special features, the transmission speed of the basic 15 lines can be increased to 600 bits per second, or as many as 16 additional lines operating in start-stop mode with speeds up to 200 bits per second may be added. However, the two features are mutually exclusive.

Data transmission is serial-by-bit with the terminals and serial-by-byte with the channel. The 2702 converts data bytes from the processing unit into bits for transmission to the terminals and assembles incoming serial data into bytes for transfer to processor storage where messages are assembled.

Functional Sections

The 2702 consists of four functional sections: interface control, common controls and storage, terminal controls, and line adapter (Figure 8-6). These functional sections perform all serializing and deserializing of transmitted characters, data control, and interface matching to common-carrier equipment.

Interface Controls Section provides the facilities for connecting the 2702 to the standard interface used by System/360.

Common Controls and Storage Section accepts commands and data bytes from the interface controls section and performs all functions common to each communications line, such as character assembly and buffering, line time out, and error control.

Terminal Controls Section performs functions associated with a given communications terminal, such as character or character sequence recognition and checking of the transmission code. One terminal control may service all attached terminals of the same type. Each 2702 requires at least one terminal control; three may be chosen.

Line Adapters Section contains one adapter (modem) for each communications line attached to the 2702. Four types of adapters are available; the choice is generally independent of the type of terminals and dependent on the communications facility specified.

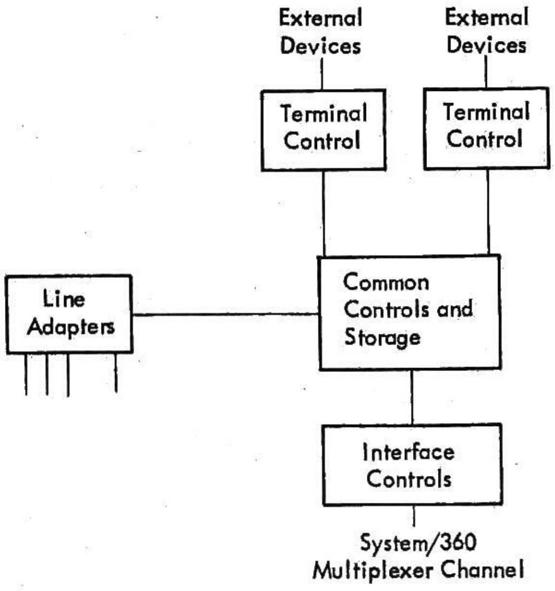


Figure 8-6. 2702 Functional Sections

Data Set Line Adapter: Provides for attachment to common-carrier leased private line or common-carrier switched telephone service.

Telegraph Line Adapter: Provides for attachment to common-carrier leased private line telegraph service.

IBM Line Adapter: Provides for attachment to privately-owned limited distance (up to 8 miles) communications facilities.

2712 Line Adapter: One adapter is required for each line operating with a 2712 Remote Multiplexer.

Special Features

Speed Extension Feature permits the 2702 to operate at speeds up to 600 bits per second when only the basic 15 lines are attached.

31 Line Expansion Feature expands the line-handling capabilities of the 2702 to 31 half-duplex lines that operate at a combined speed of 200 bits per second. The 31 Line Expansion Feature and the Speed Extension Feature cannot both be installed on any 2702.

Additional Selective Speed Feature provides for installation of an additional selective speed on terminal controls where more than one speed is available. Without this feature, a terminal control can operate terminals at one speed only.

Automatic Call Feature provides automatic dialing of remote terminals under control of the processor program.

Two Processor Switch Feature attaches one 2702 to the multiplexer channels of two System/360 processing units. The 2702 is switched between the two channels under program control.

2703 Transmission Control

The IBM 2703 Transmission Control performs functions similar to those of the 2701 Data Adapter Unit and the 2702 Transmission Control. The 2703 Transmission Control directs and controls information flow between System/360 and a variety of remote communications terminals over private and common-carrier transmission facilities.

The 2703 Transmission Control occupies one control unit position on a System/360 multiplexer channel. It requires one nonshared multiplexer subchannel for each attached half-duplex line.

The 2703 is flexible in line capacity, transmission code, and speed. The basic unit with appropriate features operates at speeds up to 600 bits per second with eight half-duplex lines attached; up to 64 more half-duplex lines can also operate with the basic unit with no loss of speed. At speeds up to 180 bits per second, the unit can operate with as many as 176 half-duplex lines. Many line-speed combinations are possible; only the system configuration determines the limitation.

The 2703 permits continuous automatic polling of most IBM terminals without causing program interruptions when negative responses are received. In communications with the attached terminals, the 2703 transmits and receives serially-by-bit and serially-by-character. Character buffering of up to four bytes can be accomplished within the unit. When communicating with the channel, the 2703 operates in multiple-byte multiplex mode to request or to transfer a group of up to four bytes each time a line requires service. On both input and output operations with the channel, any message buffering is performed by the CPU; the 2703 does not impose any restrictions on message length. All necessary bit-byte conversions, data control, and matching to common-carrier equipment are accomplished in the transmission control.

Functional Sections

The 2703 consists of five functional sections: I/O interface controls, common controls and storage, terminal controls, line bases, and line sets (Figure 8-7).

I/O Interface Controls Section connects the 2703 to the System/360 multiplexer channel. It recognizes signal sequences from the channel and returns the required sequences in response. Buffering is provided for commands from the multiplexer channel, for data going to or coming from the multiplexer channel, and for addresses from the lines requesting service.

Common Controls and Storage Section accepts commands and data from the multiplexer channel (via the I/O interface controls section) and performs functions common to all communications lines. A magnetic-core storage is provided to store control information and to buffer commands and data.

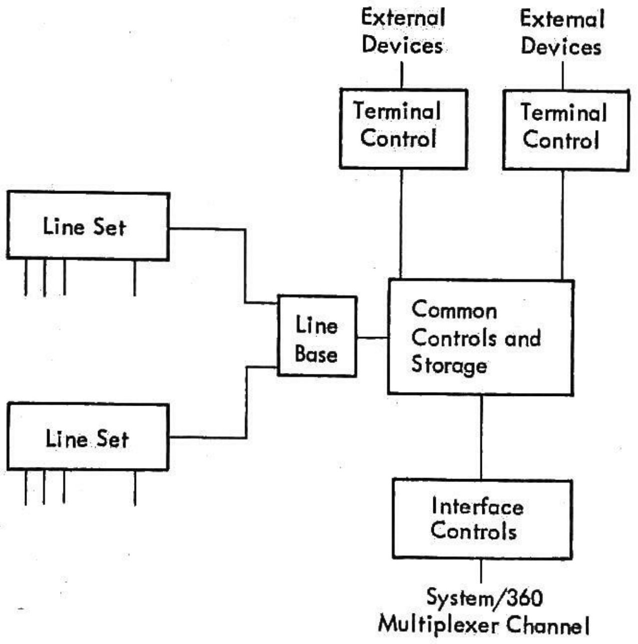


Figure 8-7. 2703 Functional Sections

Terminal Control Sections perform functions associated with a particular type of communications equipment. The terminal controls act as an extension of the common controls, performing such unique duties as character-sequence recognition, control-type character decoding, and shift-detection. At least one terminal control is required; as many as five may be chosen. Each terminal control can service all terminals of the same type.

Line Bases Section performs bit sampling. It accepts bits directly from the line adapters in a receive operation and buffers and time-multiplexes the data before sending the bits on to the common controls and storage section. The reverse procedure takes place during a transmit operation.

Line Set Sections interface the comunications facilities to the 2703 and provide bit buffering for the transmit data line. At least one line set must be used. Each line set consists of eight line adapters, with each adapter servicing one communications line. The choice of line set is generally independent of the type of terminals but dependent on the communications facility specified.

Special Features

Automatic Call Feature provides automatic dialing of remote terminals under control of the processor program.

Two Processor Switch Feature enables the 2703 to attach to two System/360 multiplexer channels. Operations occur over only one interface at a time.

Line Speed Option Feature makes available as many as seven different line speeds for use with the 2703.

2712 Remote Multiplexer Models 1 and 2

The IBM 2712 Remote Multiplexer (Figure 8-8) minimizes communications costs without reducing throughput or efficiency. It concentrates transmission from several remote terminals over one high-speed line instead of using directly attached multiple low-speed lines. The 2712 allows data transmission to proceed simultaneously in both directions between remote terminals and a System/360 equipped with either a 2702 or 2703 Transmission Control. Figure 8-9 shows a typical data communications configuration that effectively uses the 2712.

Two models of the 2712 are available. Model 1 operates with 1050, 1060, 2740, and 2741 terminals (134.5 bits per second). Ten point-to-point or multi-point low-speed lines can be attached to a Model 1. Model 2 operates with 74.2 bit per second telegraph terminals over as many as 14 low-speed lines. Terminals that operate at different transmission rates cannot be intermixed in the same 2712 network.

Figure 8-8. IBM 2712 Remote Multiplexer

The 2712 operates in the bit-multiplex mode: each of the 10 (or 14) low-speed lines is sequentially scanned, and a single bit of data is removed from each line during a scan cycle. These bits are formed into a word that is transmitted at high speed to the 2702 or 2703. For data transmitted to remote terminals, the 2712 receives a series of words from the 2702 or 2703. It separates each word into bits and places each bit on the low-speed line associated with the receiving terminal.

The 2702 or 2703 is connected to the 2712 Remote Multiplexer through a 2712 Model 1 or Model 2 Adapter. The adapter separates the high-speed line into its respective low-speed lines. The high-speed line is four-wire full-duplex; it can operate processor-to-terminal as well as terminal-to-processor. This ability permits some terminals to be transmitting while other terminals that are using the same 2712 are receiving.

The 2712 and its adapter on the transmission control are transparent to the user. Thus, in a system using these devices, System/360 is programmed as if the remote terminals were directly connected to the 2702 or 2703 by separate low-speed lines.

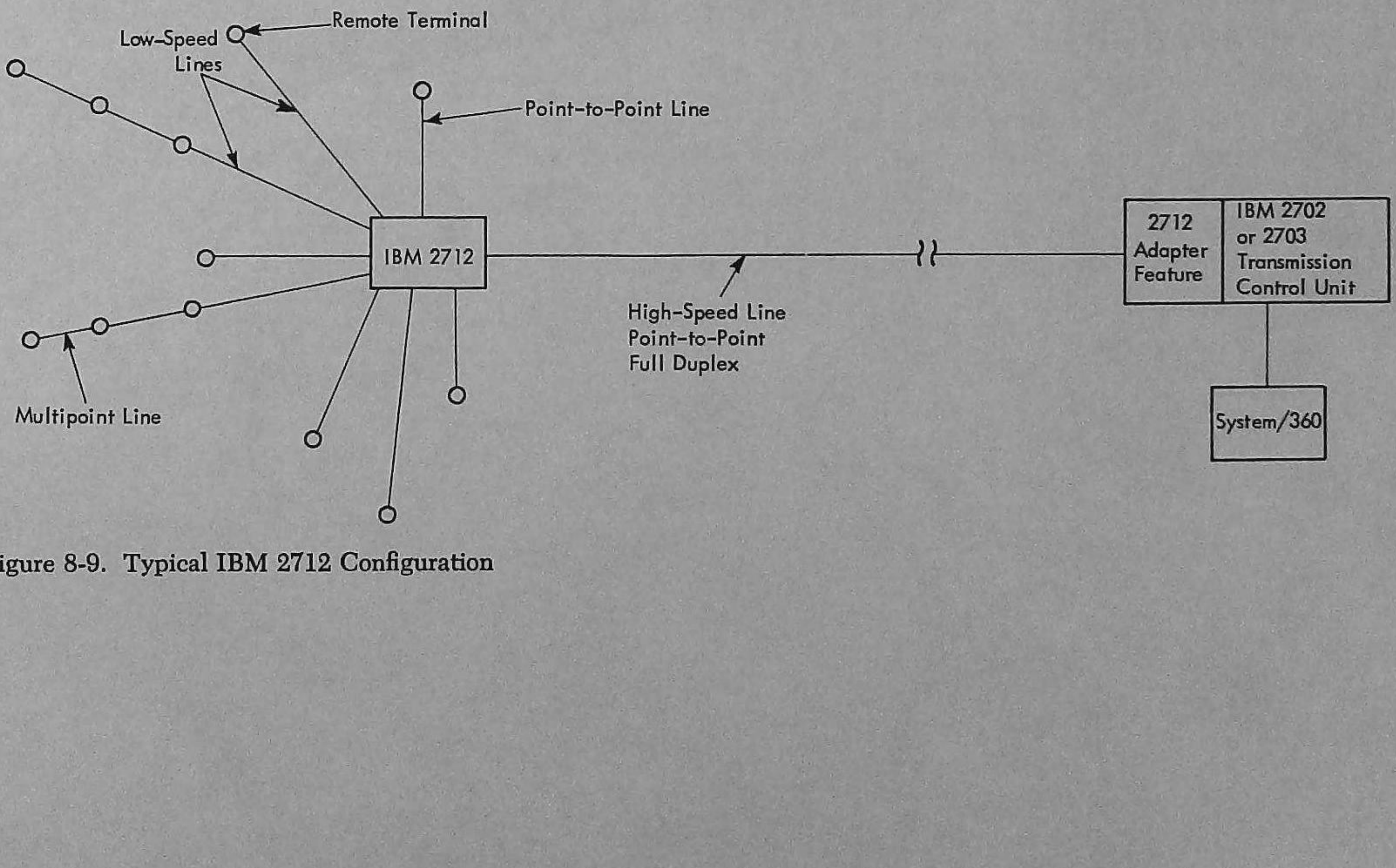


Figure 8-9. Typical IBM 2712 Configuration

Line Adapter Units

2711 Line Adapter Unit

The IBM 2711 Line Adapter Unit (Figure 8-10) enables the users of the 2702 and 2703 Transmission Controls to package IBM line adapters within one unit. Each 2711 can contain as many as 32 line adapters. The IBM line adapters modulate and demodulate signals over communications facilities in a manner similar to that of the common-carrier data sets that would otherwise be needed to perform these functions. Use of the 2711 Line Adapter Unit with IBM line adapters in lieu of common-carrier data sets offers improved flexibility of system design and economy.

Three types of line adapters can be installed. They provide facilities for:

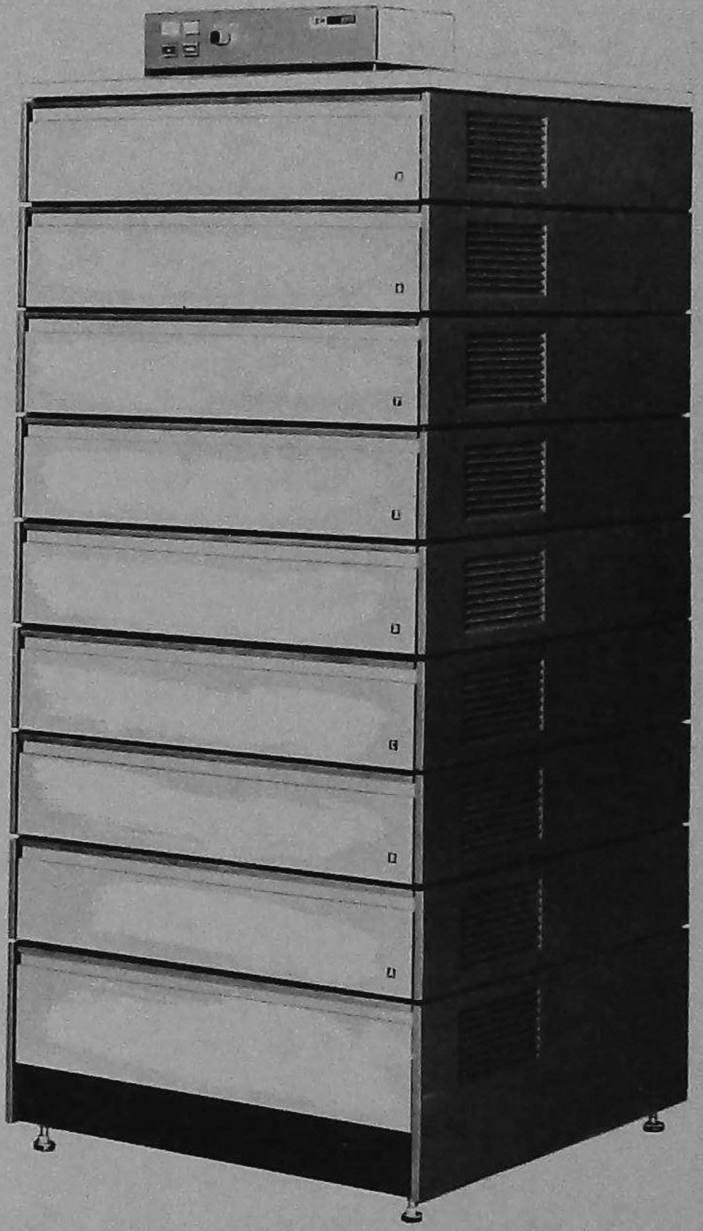
1. Communication over limited distances (8 miles or less).
2. Communication over privately owned or leased common-carrier facilities.
3. Simultaneous sharing of a voice-grade line by as many as four low-speed terminal lines. (Each low-speed line may be operated either point-to-point or multipoint.)

Functional Sections

The 2711 Line Adapter Unit contains two functional sections, the line adapter module and the line adapter.

Line Adapter Module: Each feature provides for the attachment of four line adapters. The basic 2711 can accommodate up to four IBM Line Adapters. If more than four are required, up to seven additional line adapter modules can be added to provide for a total of 32 line adapters per 2711.

Line Adapters: Line adapters enable the matching of 2702 or 2703 signals with those of the comunications line. One line adapter is required for each communications line.



● Figure 8-10. IBM 2711 Line Adapter Unit (with Maximum Number of Line Adapter Modules)

Terminals

1001 Data Transmission Terminal

The IBM 1001 Data Transmission Terminal (Figure 8-11) is a combination punched card and keyboard unit used for direct transmission to a 7770 Model 3 or a 7772 Audio Response Unit. The audio response unit is, in turn, connected to System/360 via the multiplexer channel. The 1001 transmits at 12 characters per second over common-carrier leased private line telephone service, common-carrier switched telephone networks, or privately-owned voice-grade facilities. The connection between the 1001 and the audio response unit is established by dialing a telephone.

1092 and 1093 Programmed Keyboards

The IBM 1092 Programmed Keyboard (Figure 8-12) and the 1093 Programmed Keyboard (Figure 8-13) can be connected to System/360 in two different teleprocessing configurations:

1. Over common-carrier communications facilities to either a 7770 Audio Response Unit Model 3 or a 7772 Audio Response Unit.
2. Through a 1051 Control Unit that is connected to a System/360 via communications facilities. When attached to a 1051 Control Unit, these keyboards act as an input unit and occupy a reader position.

These two keyboards can each be used alone, or they can be used in tandem. In a configuration with a 1051 Control Unit, up to two 1092's, 1093's, or 1092-1093 tandems can be attached in any combination. Transmission occurs at 14.8 characters per second. When transmitting to an audio response unit, the 1093 may be used alone, but the 1092 must be used in tandem with the 1093. Transmission to an audio response unit occurs at 12 characters per second.

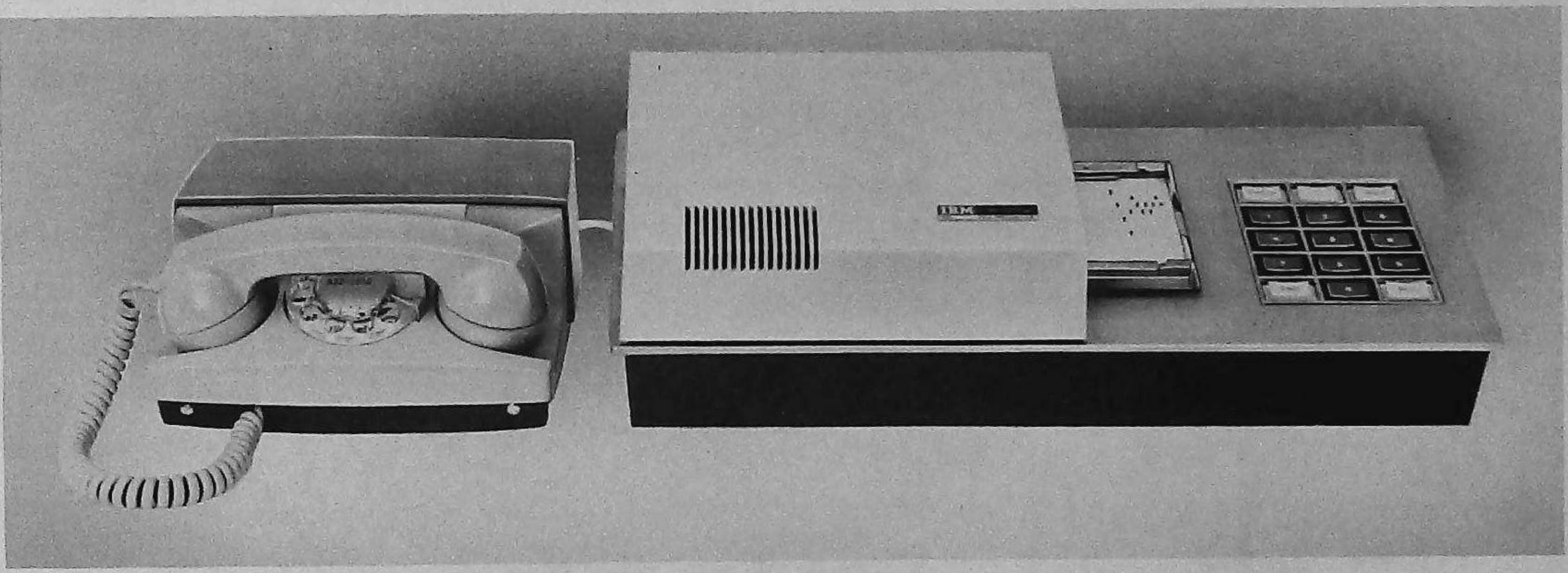


Figure 8-11. IBM 1001 Data Transmission Terminal

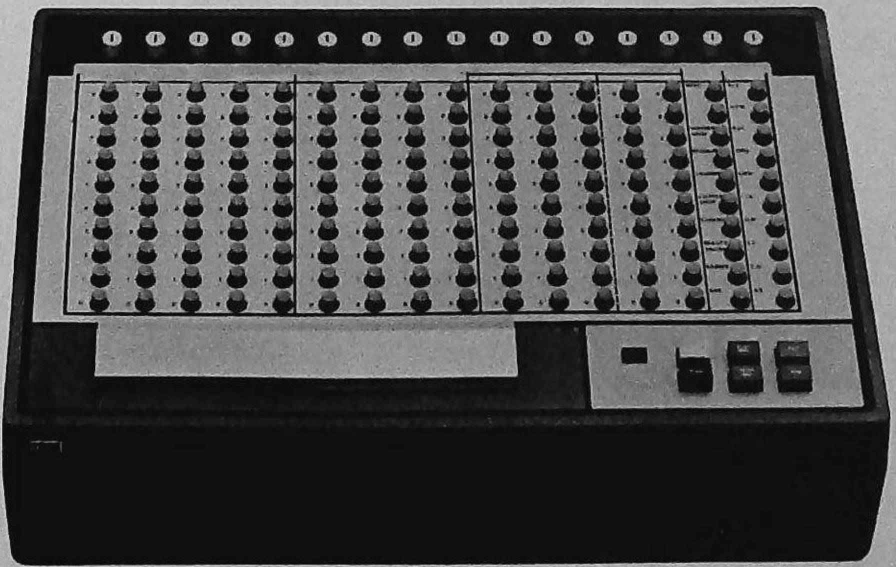


Figure 8-12. IBM 1092 Programmed Keyboard

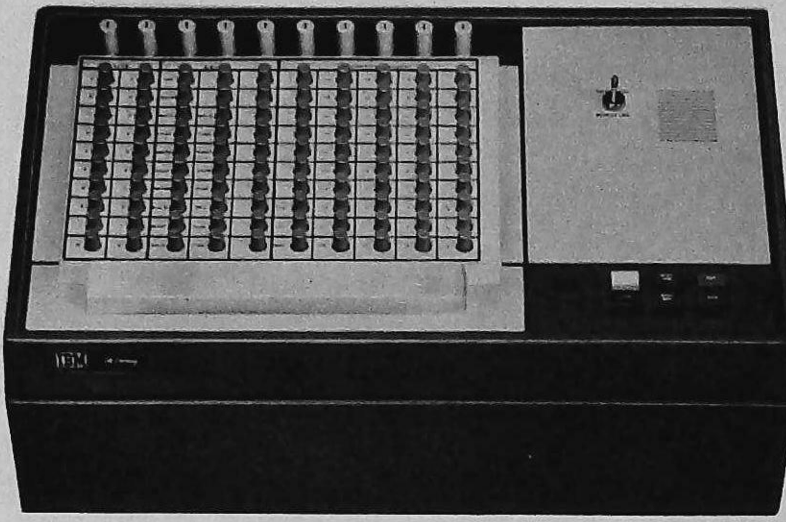


Figure 8-13. IBM 1093 Programmed Keyboard

All data entered from these keyboards can be visually checked before they are entered into the system because the data keys pressed (one per column) remain latched until manually restored. Scanning and transmission of the keyed data occur when the terminal is polled, following depression of the start button.

The 1092 and 1093 are designed to accept plastic keymats that are available from IBM. These prepunched but unprinted sheets fit over the data keys and serve as key identification. The user designs the key designations and prints them on the keymats.

Both keyboards are available in two models. The 1092 Model 1 provides 15 columns of data keys and keymat ring supports that can accommodate ten loose-leaf type keymats. The 1093 Model 1 provides ten columns of data keys and does not have keymat ring supports. Model 2 of both the 1092 and 1093 provides a sensing unit on the keyboard directly below the data keys. This unit senses as many as 48 differently coded keymats which can each be used individually with these Model 2 keyboards. In addition to having this sensing unit, the 1092 Model 2 provides 16 columns of data keys and does not have keymat ring supports.

2740 Communication Terminal Models 1 and 2

The IBM 2740 Communication Terminal (Figure 8-14) features a SELECTRIC® typewriter appropriately modified for use as a general-purpose communication terminal. Thus, the 2740 can function alternately as a typewriter (local mode) or as a data sending and receiving unit (communicate mode).

Data is transmitted in half-duplex mode over the attached communication lines. The maximum transmission rate is 14.8 characters per second for the 2740-1 and 60 characters per second for the 2740-2. Effective transmission rates may be less, because varying typing speeds affect the 2740-1 operating speed. Special features available for the 2740-2 may also increase or decrease the transmission rate. In either mode, the 2740 can be operated by any typist with a minimum of additional training. System control keys and indicator lights are conveniently located alongside the typewriter keyboard.

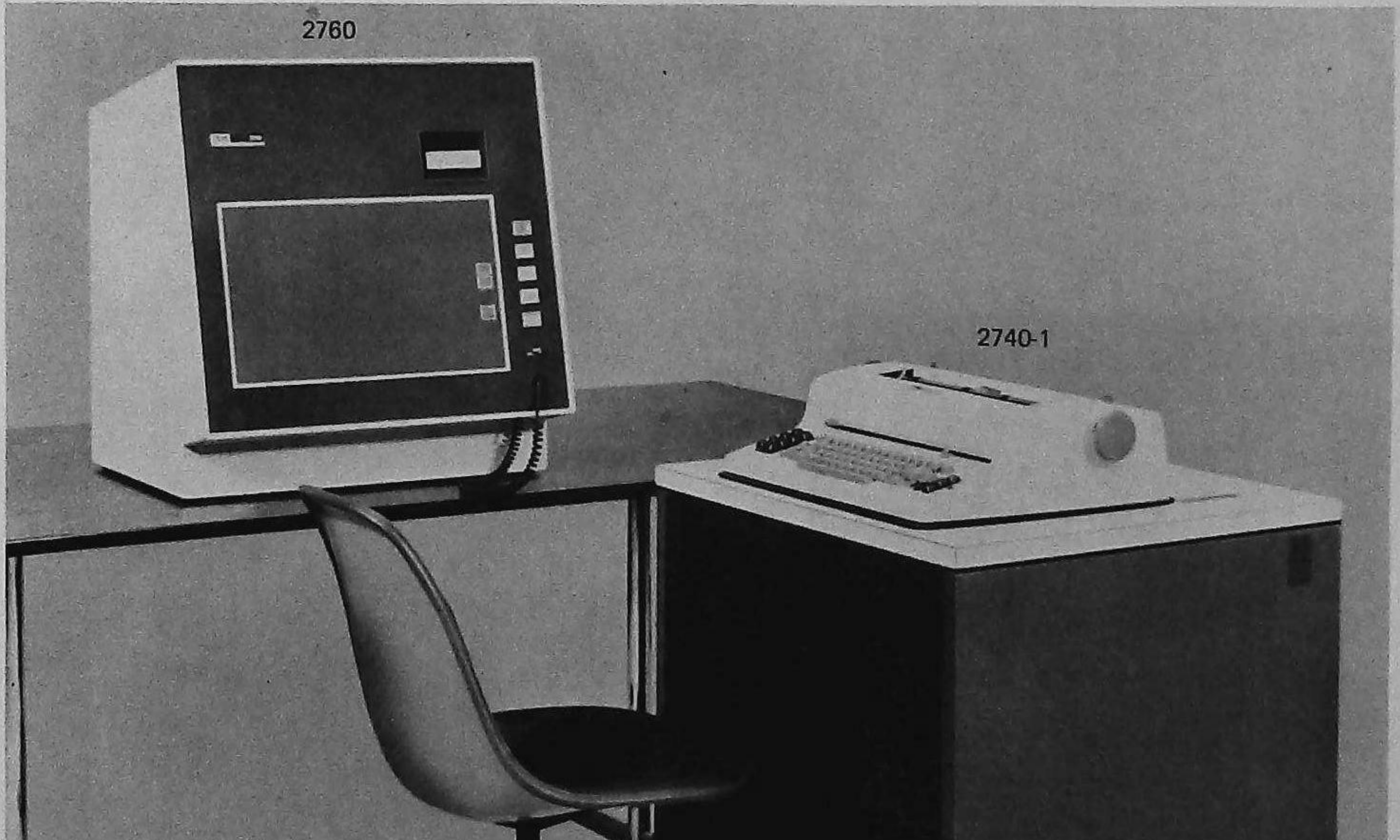


Figure 8-14. IBM 2740 Communication Terminal Model 1 with IBM 2760 Optical Image Unit

The 2740 is available in two models. The 2740-1 can communicate with other 2740-1 terminals directly or with System/360; the 2740-2 is designed exclusively for communication with System/360.

The types of operation that can be specified for the 2740-1 are:

1. Between two terminals over either leased common-carrier private line channels or common-carrier switched networks.
2. Between a terminal and a System/360 over the above-mentioned facilities.
3. Between a terminal and two or more other terminals over leased common-carrier private line channels.
4. Between a System/360 and two or more terminals over leased common-carrier private line channels.

When the 2740-1 is operating in communicate mode, each message character keyed at the sending terminal is printed at both the sending and receiving terminals. The 2740-2 is designed to enable the key input from the typewriter keyboard to be printed at the sending terminal, stored in a buffer, and subsequently transmitted to a System/360.

The buffer storage on the 2740-2 provides improved operation through:

Faster transmission to and from the CPU buffer.
Visual verification before transmission.
Easier correction of keying errors.

Some of the many applications for which the 2740-1 is designed are:

Intracompany Communication: Internal communication between company departments can be easily handled with the 2740-1.

Intercompany Correspondence: To aid in sales and to expedite customer orders, a 2740-1 can be installed in the purchasing department of major customers.

Executive Correspondence: Effective two-way communication can be easily maintained between the executive offices and the sales or manufacturing locations by using the 2740-1.

Remote Inquiry and Reply: Using the 2740-1, persons having access to a central processing unit can handle inquiry and reply operations without leaving their department areas.

The buffer storage on the 2740-2 makes it particularly well-suited for remote inquiry and reply operations. Among the specific uses for this model are: payment entry, journal entry, administrative messages, file updating, and record renewal.

2741 Communication Terminal

The IBM 2741 Communication Terminal (Figure 8-15) is a modified SELECTRIC® typewriter with electronic controls that enable it to operate as a remote conversational terminal, thus permitting direct access to System/360. The 2741, when it is not being used for communication, may be used for normal office typing. Intended primarily for text-handling and scientific applications, the 2741 Communications Terminal permits persons at remote points to utilize the problem-solving capability of System/360 on a time-sharing basis. (See "Time Sharing" in Section 4.) Some of the uses the terminal may be used for are:

On-line scientific computation
On-line computer programming
Text handling (especially technical writing, proposal writing, and editing)

The 2741, considered by itself, is a typewriter capable of encoding the characters typed and presenting the signal to a communications channel. Therefore, the applications of this terminal are mostly determined by the program used by the System/360 with which it is associated.

The 2741 can communicate over half-duplex circuits with System/360 via a 2701 Data Adapter Unit, a 2702 or 2703 Transmission Control, or a 2712 Remote Multiplexer. Only one 2741 Terminal can be attached to a communications line.

One central processing unit can service many 2741's. The maximum number of terminals that can be used in one configuration depends on either the communications facilities selected or the capacity and equipment of the computer system.

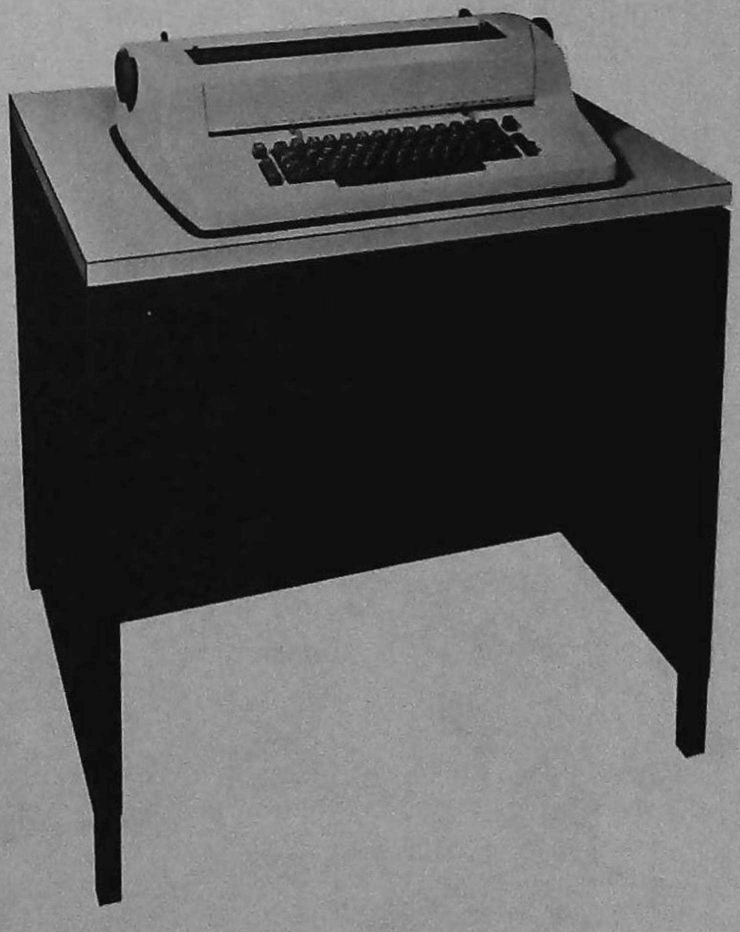


Figure 8-15. IBM 2741 Communication Terminal

2760 Optical Image Unit

The IBM 2760 Optical Image Unit (Figure 8-14), an I/O attachment for a 2740 Communication Terminal Model 1, provides the user with the capability of entering visual data into a remotely located computer.

The 2760 operates on-line, providing input data to a central processing unit (CPU) by way of an image projection screen and a radio-frequency (RF) probe. The operator needs no keyboard training; he needs only the ability to recognize illustrations (color or black and white) or words, phrases, and sentences in his own language. All the data used for a job may be displayed on the dual-purpose screen.

To communicate with the computer, the operator points the probe at an appropriate location on either half of the screen. The right half displays data projected from a 16-millimeter filmstrip mounted in a cartridge. The cartridge is easily inserted or removed by the operator. Each filmstrip may contain up to 151 images, of which 128 can be specially tailored to a customer's applications. Film feeding is either under operator control or computer program control. In either case, an image counter keeps the CPU program aware of the film frame being viewed. The left half of the screen displays a set of auxiliary response points, used to enter fixed or semi-fixed data, any group of which may be called for in a particular job. A job may require one or more patterns of response points, each pattern labeled by an overlay. Each side of the screen has 120 possible response points, positioned in a 10 by 12 matrix.

Each response of the probe is transmitted as a pair of coordinates for a given frame and can represent a number, word, phrase, or sentence. The CPU program translates the coordinates into meaningful data.

A single selection from an image displayed on the screen results in data identification, transaction classification, and entry of this data into the system – all in the operator's language, which could be Spanish, Japanese, French, or any other desired by the customer.

2780 Data Transmission Terminal

The IBM 2780 Data Transmission Terminal (Figure 8-16) enables large volumes of card data to be transmitted at line speeds with punched or printed output. It consists principally of a printer similar to the 1443 Printer; a card read punch similar to the 1442 Card Read Punch; a line buffer that stores data received, or to be transmitted, over a communications line; and a binary synchronous adapter, which controls the flow of data over the communications lines and maintains synchronization between the transmitting and receiving terminals.

The 2780, available in four models with any of three codes, permits a variety of system configurations. The four models are:

Model 1–Card read or print
Model 2–Card read or card punch or print
Model 3–Print only (used as a receiving terminal only)
Model 4–Card read or card punch

Models 1-3 print at a maximum speed of 300 lines per minute. The actual speed depends on the communications facilities used and the number of characters in the character set:

39-character set–300 lines per minute
47/52-character set–240 lines per minute
63-character set–200 lines per minute

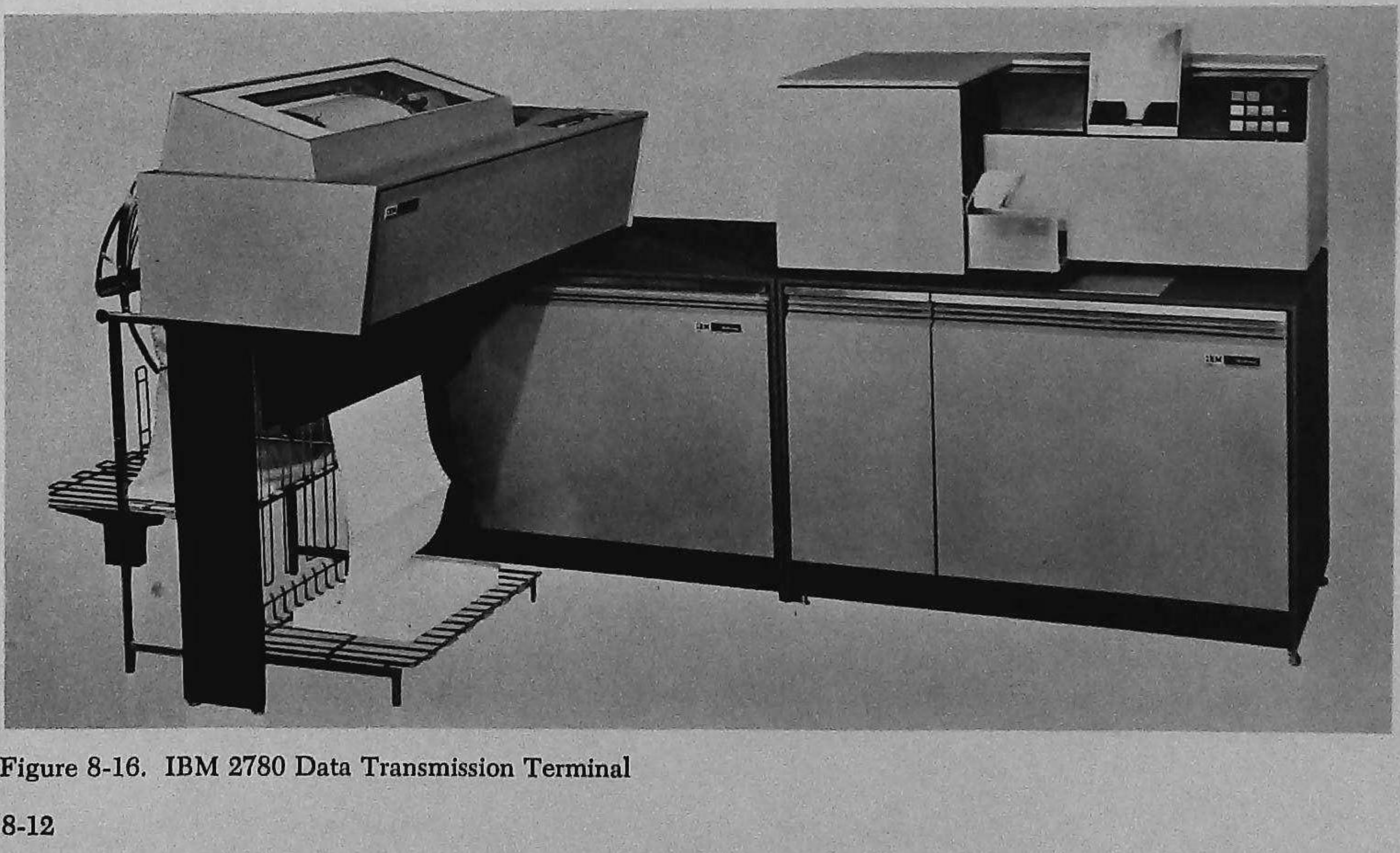


Figure 8-16. IBM 2780 Data Transmission Terminal

Models 1, 2, and *4* read at a maximum speed of 400 cards per minute; each contains one card stacker.

Models 2 and *4* punch at a maximum speed of 355 cards per minute.

The actual throughput speed of the card read punch depends on the number of card columns that are read or punched, the code used, and the communications facilities selected.

The 2780 can also be used off-line to perform a card-reader-to-printer listing operation. The 2780 is capable of operating with any one of three code structures. The choice depends on the application. However, for system compatibility, the same code must be chosen for all terminals on a particular communications line. The three available codes are: the six-bit transcode (six-bit transmission code), EBCDIC (extended binary coded decimal interchange code), and USASCII (U.S.A. Standard Code for Information Interchange).

The communication can be point-to-point with another 2780 (Figure 8-17), or it can be either point-to-point or multipoint (special feature) with the System/360 through a 2701 Data Adapter Unit or a 2703 Transmission Control Unit (Figure 8-18). The 2701 Data Adapter Unit must be equipped with a synchronous data adapter type II (SDA-II), and the 2703 Transmission Control Unit must be equipped with a synchronous base type 1A or 1B adapter. The 2780 operates in half-duplex mode over any of the following five communications facilities:

1. Common-carrier switched telephone network
2. Common-carrier leased private line telephone service, either two-wire or four-wire
3. Western Union class E channels
4. Western Union Class F channels
5. Privately-owned communications facilities

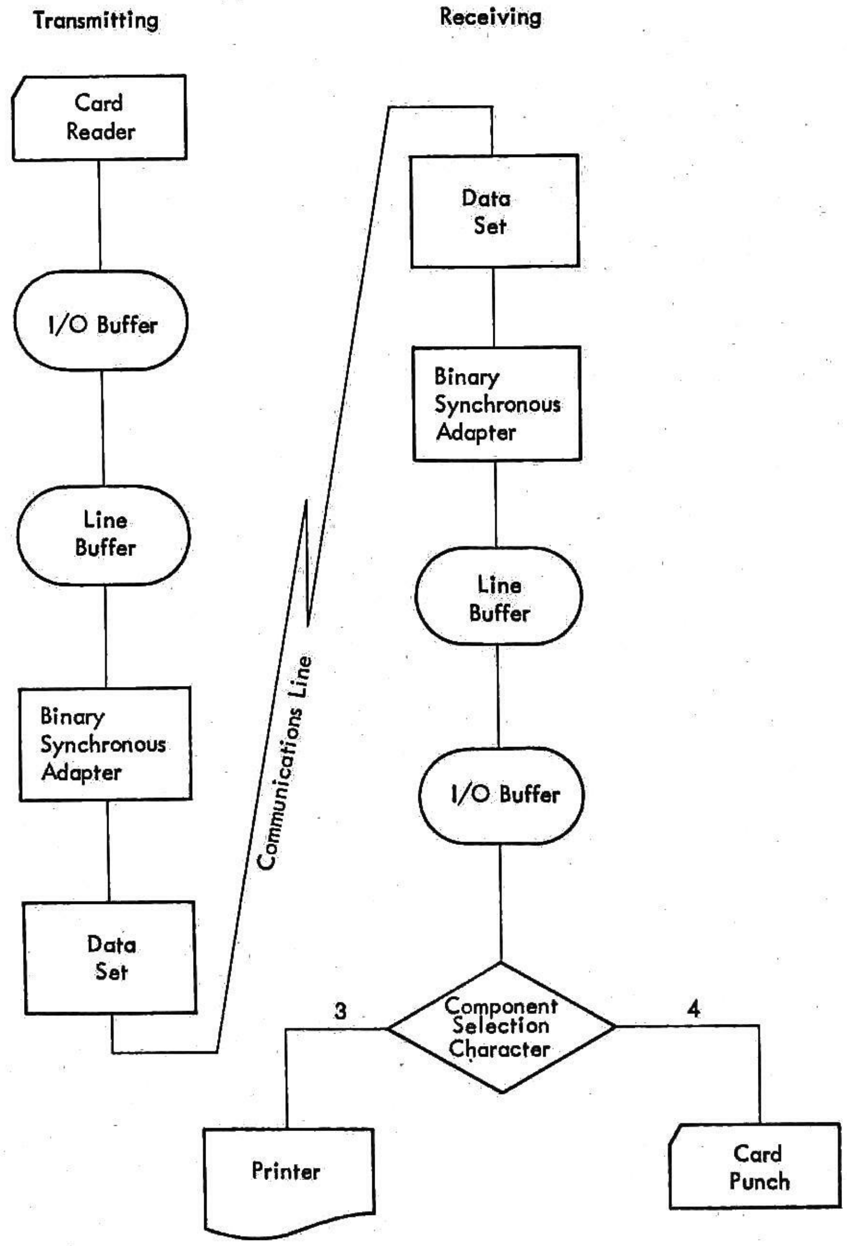


Figure 8-17. Data Flow, Terminal-to-Terminal Operation

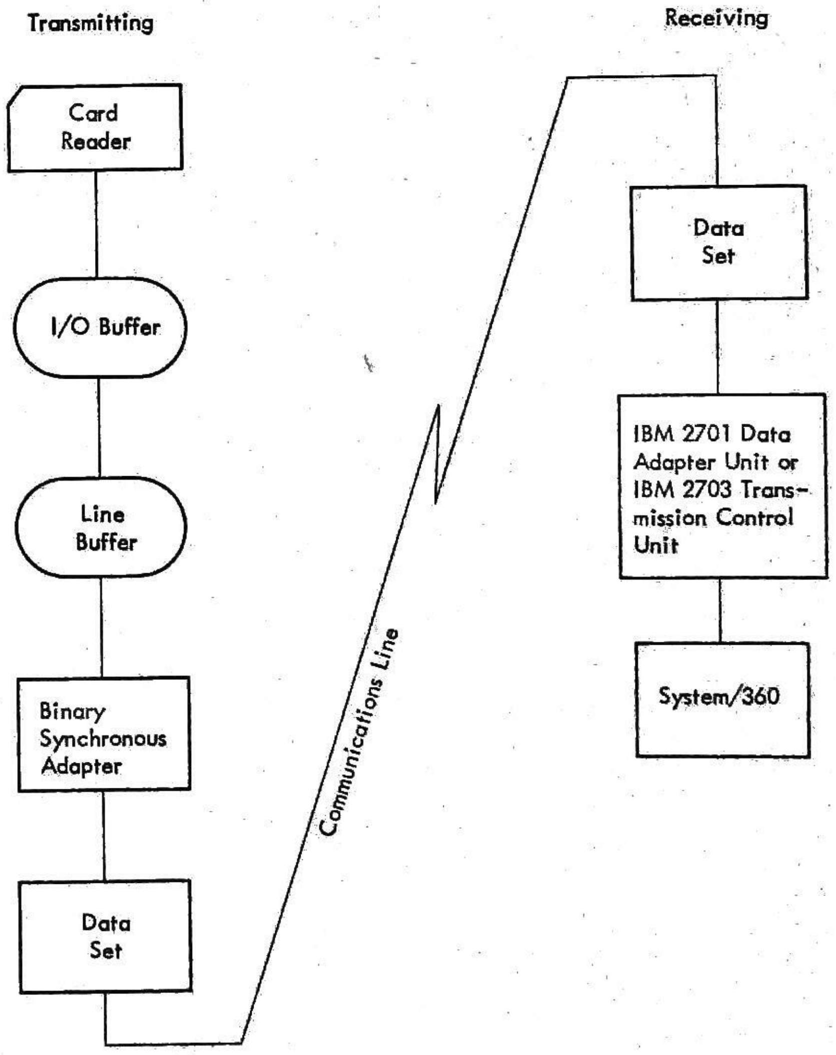


Figure 8-18. Data Flow, Terminal-to-Computer Operation

Display Devices

• 2260 Display Station Models 1 and 2; 2848 Display Control Models 1, 2, 3, 21, and 22

The IBM 2260 Display Station operates through the IBM 2848 Display Control in both local and remote applications. In remote applications, the 2848 communicates with a central System/360 installation via common-carrier communications facilities, a 2701 Data Adapter Unit, and appropriate data sets.

A choice of two data set adapters permits data transmission, in duplex mode, at 1,200 or 2,400 bits per second (120 or 240 bytes per second). The bytes include the start, stop, and check bits transmitted with each seven-bit character.

For more information about the 2260 and 2848, see "Display Devices," in Section 7.

2265 Display Station; 2845 Display Control

An IBM 2265 Display Station (Figure 8-19), coupled with an IBM 2845 Display Control, forms a display system that provides rapid visual access (via communications facilities) to data stored in a remotely located System/360. This display system is ideally suited to applications that require immediate data acquisition capabilities at a relatively low cost. Inquiries concerning an account, a transaction, or a production schedule can be sent quickly and easily to a remote System/360 from the keyboard of the 2265. After computer processing, the desired visual data is displayed on the 2265 screen and can then be analyzed, modified if necessary, and when desired, returned to the computer for further processing and storing.

The 2265/2845 display system is similar in function to the 2260/2848 display system and is fully compatible with those units. A possible 2265/2845 configuration is shown in Figure 8-20. Note that only one 2265 can be attached to a 2845.

The 2265 contains a 14-inch cathode-ray tube on which as many as 960 alphameric characters can be displayed. Two display formats are available: 15 lines with 64 characters per line (10.4 inch by 4.8 inch frame) and 12 lines with 80 characters per line (10.4 inch by 3.12 inch frame). The 2265 is equipped with an alphameric keyboard, which can be located up to 5 feet from the display screen.

A nondestructive cursor, an automatically inserted visual marker denoting the position on the 2265 screen that the next character to be entered will occupy, is standard on the 2265. It appears as ∧__ immediately below the next character to be entered and may be moved about freely without interference to characters on the screen. The destructive cursor, an optional feature, appears on the screen as a heavy horizontal bar (▬). When the destructive cursor is moved to a character position containing a character, the character is erased.

The 2845 is designed for remote attachment to a System/360 I/O channel through a 2701 Type III Communications Adapter. The 2845 transmits data over

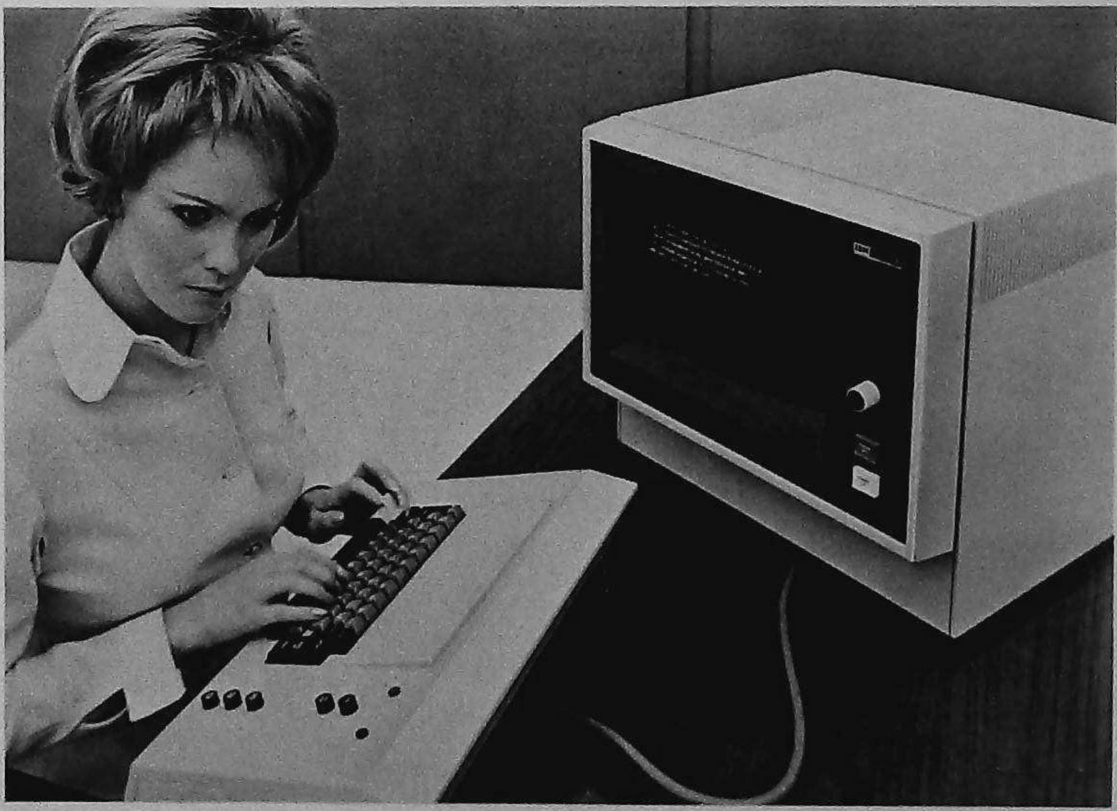
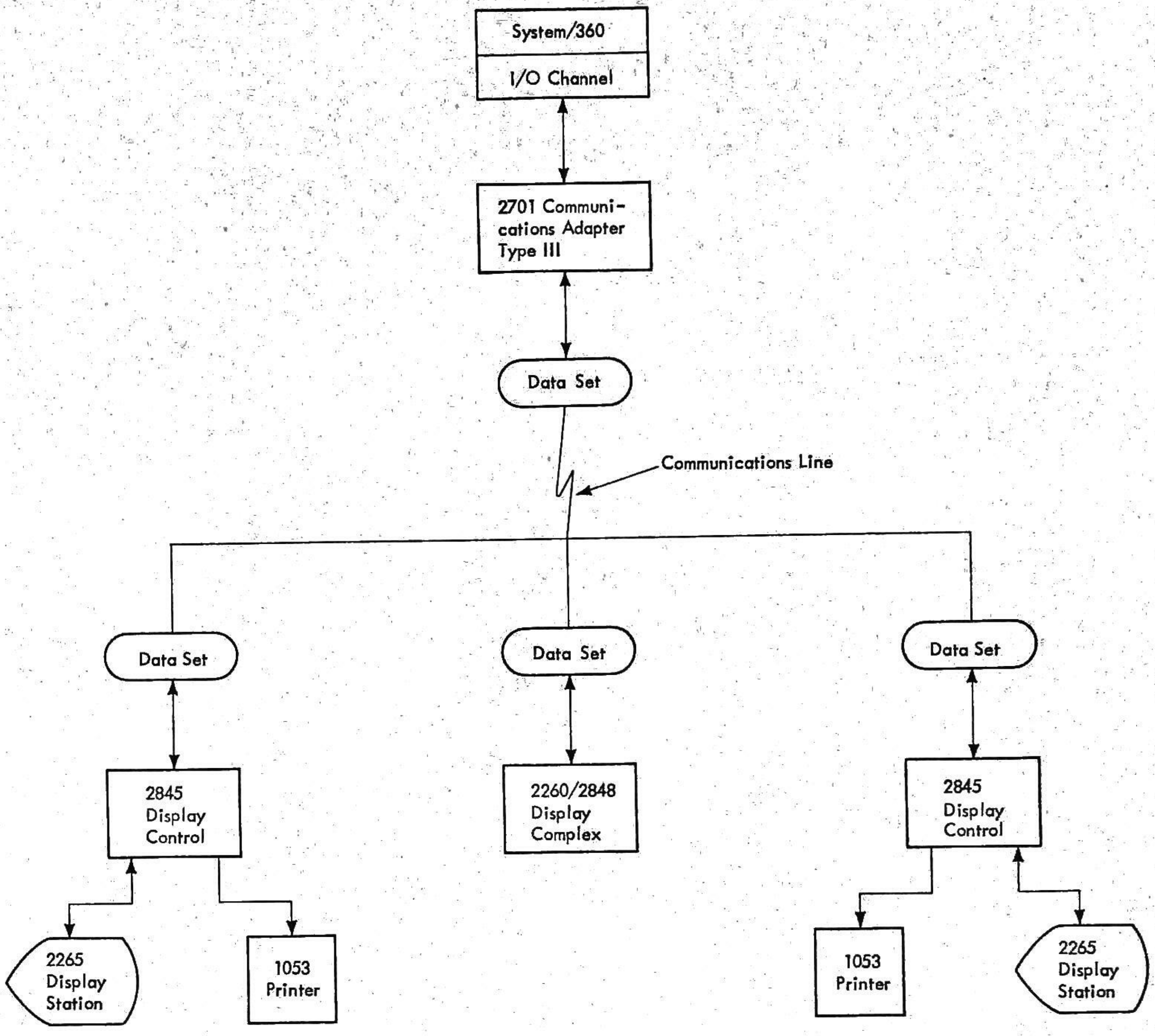


Figure 8-19. IBM 2265 Display Station with Alphameric Keyboard



Note: A maximum of sixteen 2845's may be attached to the same communications line.

Figure 8-20. Typical Connection on an IBM 2845 Display Control to a Remote CPU in a Multidrop (Multistation) Communications Network

ordinary leased telephone lines in stop/start, half-duplex mode at speeds of 1,200 or 2,400 bits per second. As many as sixteen 2845's may be attached to the same communications line.

An optional line addressing feature and a 1053 adapter feature are available. The line addressing feature permits the writing of a CPU-generated message to begin at the start of any chosen line. The 1053 adapter feature permits the attachment of a 1053 Printer Model 4 to a 2845 Display Control for obtaining paper copy of data sent from the CPU or displayed on the 2265 screen.

Systems

1030 Data Collection System

The IBM 1030 Data Collection System (Figure 8-21) provides a fully integrated on-line data collection system, capable of operating within one plant or between plants. The various components of the 1030 system together form an effective management information system that diminishes the gap between the time when data is originated and the time when it becomes available for use. Some of the applications of the 1030 system include:

Scheduling
Dispatching
Attendance reporting
Inventory maintenance
Labor distribution and performance

The 1030 system collects digital information from diverse reporting stations and transmits it at 60 characters per second to a central System/360 for recording, processing, and analyzing.

Connection to the System/360 is effected via either the 2701 Data Adapter Unit or the 2702 or 2703 Transmission Control. Transmission occurs over half-duplex privately-owned communications lines or common-carrier leased private lines.

The specific units that may be combined into a 1030 configuration are:

IBM 1031 Input Station
IBM 1032 Digital Time Unit
IBM 1033 Printer (on-line systems only)
IBM 1034 Card Punch (off-line systems only)
IBM 1035 Badge Reader

1031 Input Station enables the 1030 system to accept input data in various forms; the system can accept alphameric data from standard 80-column punched cards and numeric data from punched plastic badges, manual entry units, and data cartridges. As many as many as 24 IBM 1031's can be attached to a 1030 system.

1032 Digital Time Unit provides time-of-day information for the entire data collection system.

1033 Printer provides on-line 1030 Data Collection Systems with printed output at locations remote from the central System/360. 1033 printers, in combination with 1031 input stations, offer full on-line inquiry and reply capabilities with the System/360 processing unit.

1034 Card Punch is the transmission control and output unit for the off-line 1030 system. When the system is designed for off-line use, there is no connection to System/360. Instead, the 1034 Card Punch co-

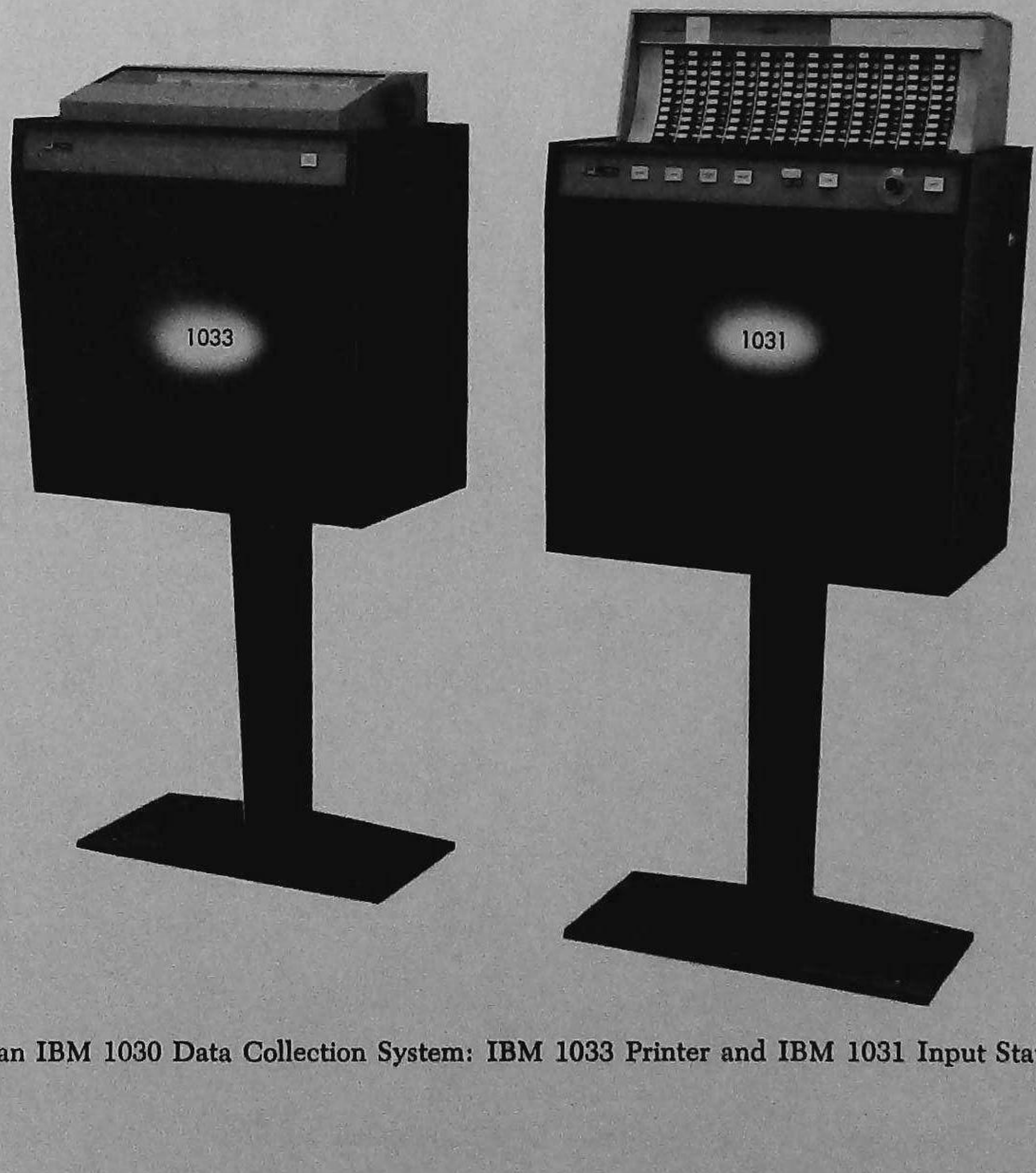


Figure 8-21. Units of an IBM 1030 Data Collection System: IBM 1033 Printer and IBM 1031 Input Station

ordinates transmission from the remote stations and punches standard 80-column cards as output records.

1035 Badge Reader transmits numeric data at 60 characters per second from 22-column (card-stub size) badges via a 1031 Input Station. As many as four 1035's can be connected to a 1031. Functionally, the 1035 Badge Reader units can be thought of as providing an extension of the badge reading capability of the 1031 unit with which they are associated.

1050 Data Communication System

The IBM 1050 Data Communication System (Figure 8-22) is a multipurpose office-oriented teleprocessing system. This versatile system is designed for a wide range of applications in such industries as:

Transportation
Manufacturing
Research
Distribution
Insurance
Refining

In particular, the 1050 system can perform such functions as:

Document Writing of sales order, insurance policies, payrolls, engineering specifications, etc.

Direct Inquiry and Response (real-time operation) with a central processing unit.

Remote Printing of business records and invoices, thus supplying to remote locations full documentation of business transactions.

Exception Reporting of data about work orders, credit ratings, inventory adjustments, traffic movements, etc.

Intracompany Communication to provide rapid distribution of memorandums, directives, administrative reports, etc.

The 1050 Data Communication System can be connected to System/360 via the 2701 Data Adapter unit, the 2702 or 2703 Transmission Controls, or the 2712 Remote Multiplexer. A special feature allows direct connection of some 1050 system components to a System/360 Model 30. Transmission can occur at 14.8 characters per second in half-duplex mode over leased private, common-carrier switched, or privately owned telephone networks; and either directly between locations, through switching centers, or through message exchanges. The 1050 system is capable of simultaneous home-loop operation (local operation between units of the same 1050 configuration) and line-loop operation (over communications lines to another 1050 system or the System/360).

Data may be entered into the 1050 system by manual keying, by punched cards, by punched paper tapes, and by edge-punched documents. Output from the system may be printed documents, punched cards, punched paper tape, or edge-punched documents.

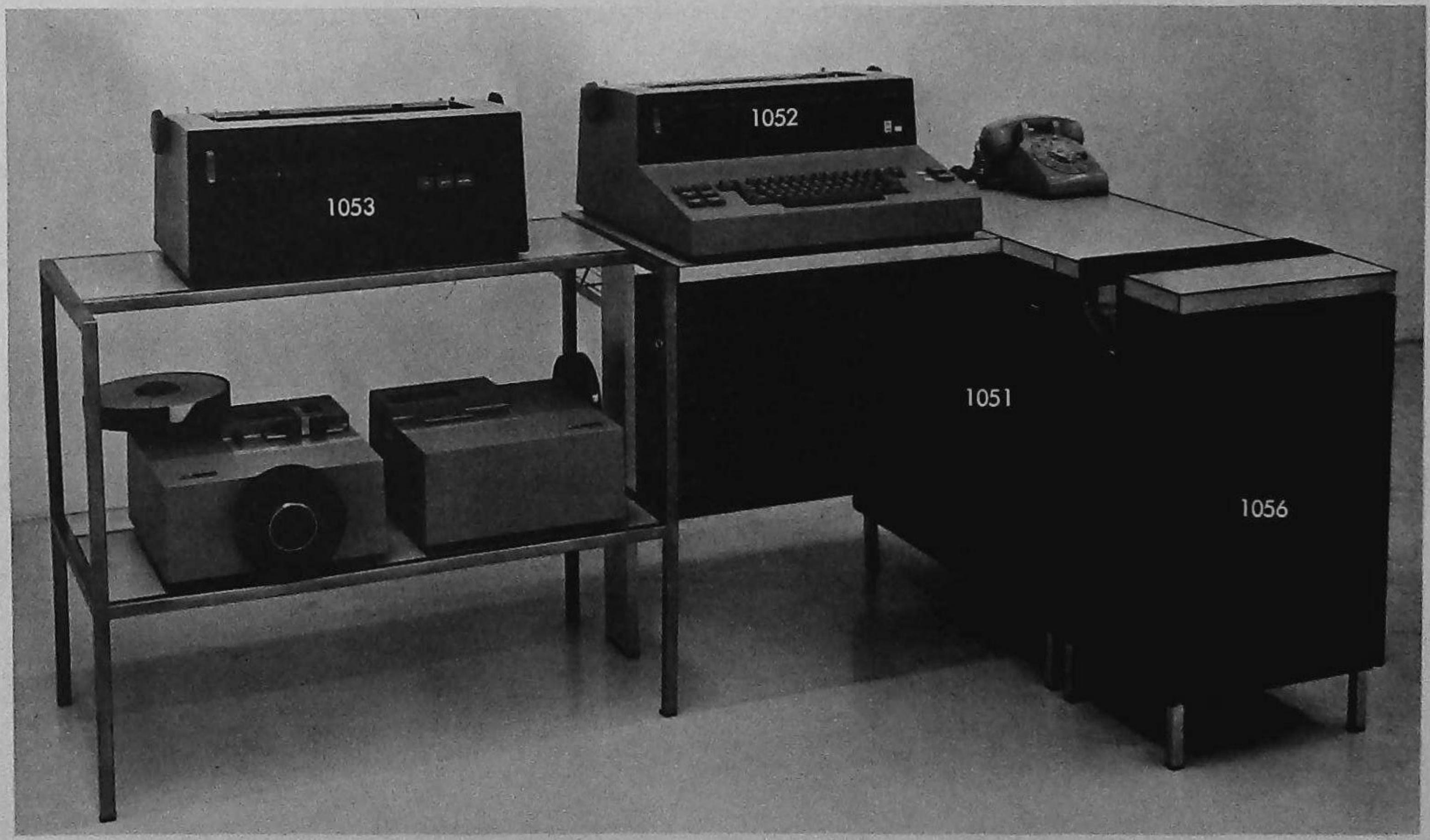


Figure 8-22. IBM 1050 Data Communication System

The versatility of the 1050 system is due in large part to the many configurations it may assume. The minimum configuration contains only an IBM 1051 Control Unit and a receive-only printer; configurations for a wider variety of uses may be designed from combinations of the following available components:

1051 Control Unit
1052 Printer-Keyboard
1053 Printer
1054 Paper-Tape Reader
1055 Paper-Tape Punch
1056 Card Reader
1057/1058 Card Punch or Printing Card Punch
1092 and 1093 Programmed Keyboards

The 1051 Control Unit is required in all configurations. It contains the power supply, code translator, data channels, and control circuitry for the 1050 system. All components are electrically connected through the control unit.

For information about the direct connection of 1050 system components to System/360, see the descriptions of the 1051 Control Unit and the 1052 Printer-Keyboard under "Manual Controls" in Section 7. For information about the 1092 and 1093 Programmed Keyboards, see "1092 and 1093 Programmed Keyboards" in Section 8.

1060 Data Communication System

The IBM 1060 Data Communication System (Figure 8-23) improves services in such institutions as savings banks, savings and loan associations, and commercial banks. It brings the speed and power of the modern computer to the tellers' windows of these institutions, efficiently performing the many accounting functions associated with any particular bank transaction. With this system, any teller, at any window, both at the bank's main office and at its widely scattered branch offices, can access all necessary records for any customer. As the daily transactions proceed, the 1060 system provides each customer with an accurate, updated record of his account. The system also provides each teller with this same account information and continuously maintains his balance on hand.

Using the IBM 1062 Teller Terminal, a teller can key transaction information from his window to a remotely located System/360. After System/360 has verified the accuracy of the transmitted information and updated its records, it causes the teller terminal to print out on a customer's passbook any unposted interest, the current transaction amount, and the new balance in his account. The terminal also prints a complete record of both the transmitted and received data on the teller's terminal-record tape. If the system discovers any exception conditions, such as an account tied up in estate or uncollected funds, it immediately informs the teller of these conditions.

The 1060 system, when joined via communications lines with a System/360, forms a complete teleprocessing system. To the System/360, the 1060 appears as an input/output device. Connection of the two systems requires either a 2701 Data Adapter Unit or a 2702 or 2703 Transmission Control. Transmission can occur at 14.8 characters per second in half-duplex mode. An odd parity BCD code is used for transmission.

The 1060 system comprises two compact units:

IBM 1061 Control Unit: The 1061 is basically the electronic unit of the system. It contains the central logic, code translators, accumulators, data channels and control circuitry for the system and supplies power to the 1062. The 1061 supplies the line control governing transmission of data to and from a 2701, 2702, or 2703.

A 1061 Model 1 controls one 1062 Teller Terminal Model 1. A 1061 Model 2 controls one 1062 Model 1 and one 1062 Model 2 or, if the off-line feature is installed, two 1062 Model 1's.

IBM 1062 Teller Terminal: The 1062 is basically the mechanical unit of the system. The 1062 contains a print unit, a terminal-record tape, a document feed, a keyboard, a program tape unit (Model 1 only), and

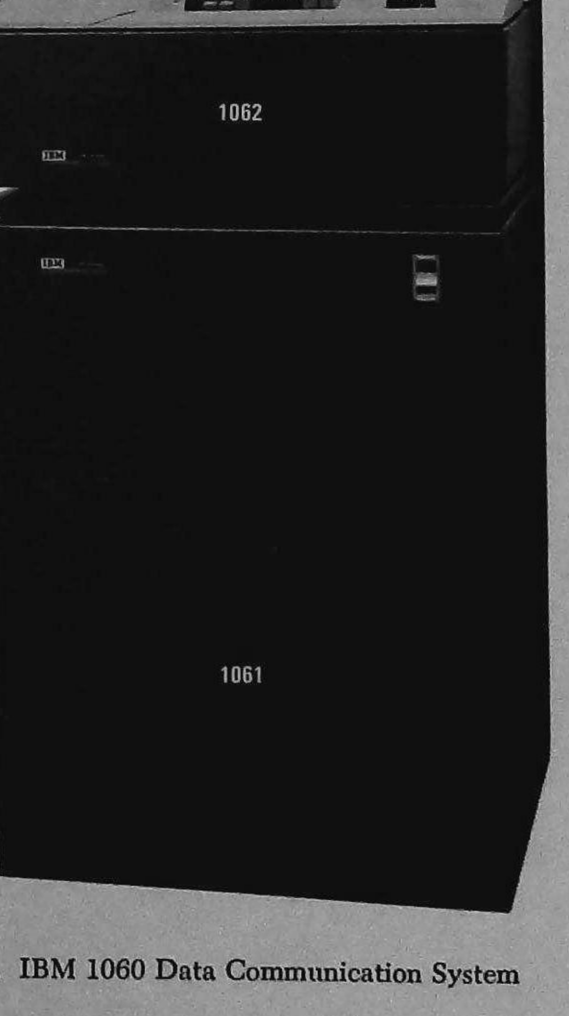


Figure 8-23. IBM 1060 Data Communication System

various keys, lights and switches. Each 1062 terminal can serve two tellers.

Off-Line Operation

Even if communications cannot be maintained between the 1060 system and the System/360, the 1060 can continue to operate by going off-line. When the 1060 is off-line, it is under control of a punched program tape that is a part of the 1062 Teller Terminal Model 1. The program tape instructs the 1061 Control Unit to perform the arithmetic functions necessary to process transactions and to develop new passbook balances. During off-line operation all customer transactions proceed normally without reference to System/360. When communications between the two systems are restored, transactions that were handled off-line are entered into the data processing system, which then updates its account records.

Among the features available on the 1060 system is an adding machine feature, which allows the use of the teller terminal as an adding machine; this feature is included if the terminal has the capability of going off-line. A check writing feature permits the insertion of checks into the document feed for amount printing.

1130 Computing System

The IBM 1130 Computing System, when equipped with a synchronous communications adapter, can function as a remote processor terminal to a centrally located System/360 and as a local stand-alone computer, and can easily switch from one function to the other.

The 1130 itself, an economical and compact general-purpose system, is particularly easy to use. The person needing computer solutions to his problems can learn to use the system with a minimum of training and experience. In addition, IBM relieves the user of detailed programming and provides for the statement of problems in familiar langauge.

Basic 1130 Computing System

The basic system consists of an IBM 1131 Central Processing Unit (Figure 8-24) with an integral console printer and keyboard, and either punched card or paper tape I/O devices. The central processing unit (CPU) contains main storage, logic circuits, and attachment controls for the I/O devices. The 1131 uses a high-speed data channel for effective simultaneous operation of I/O devices. This unit features parallel

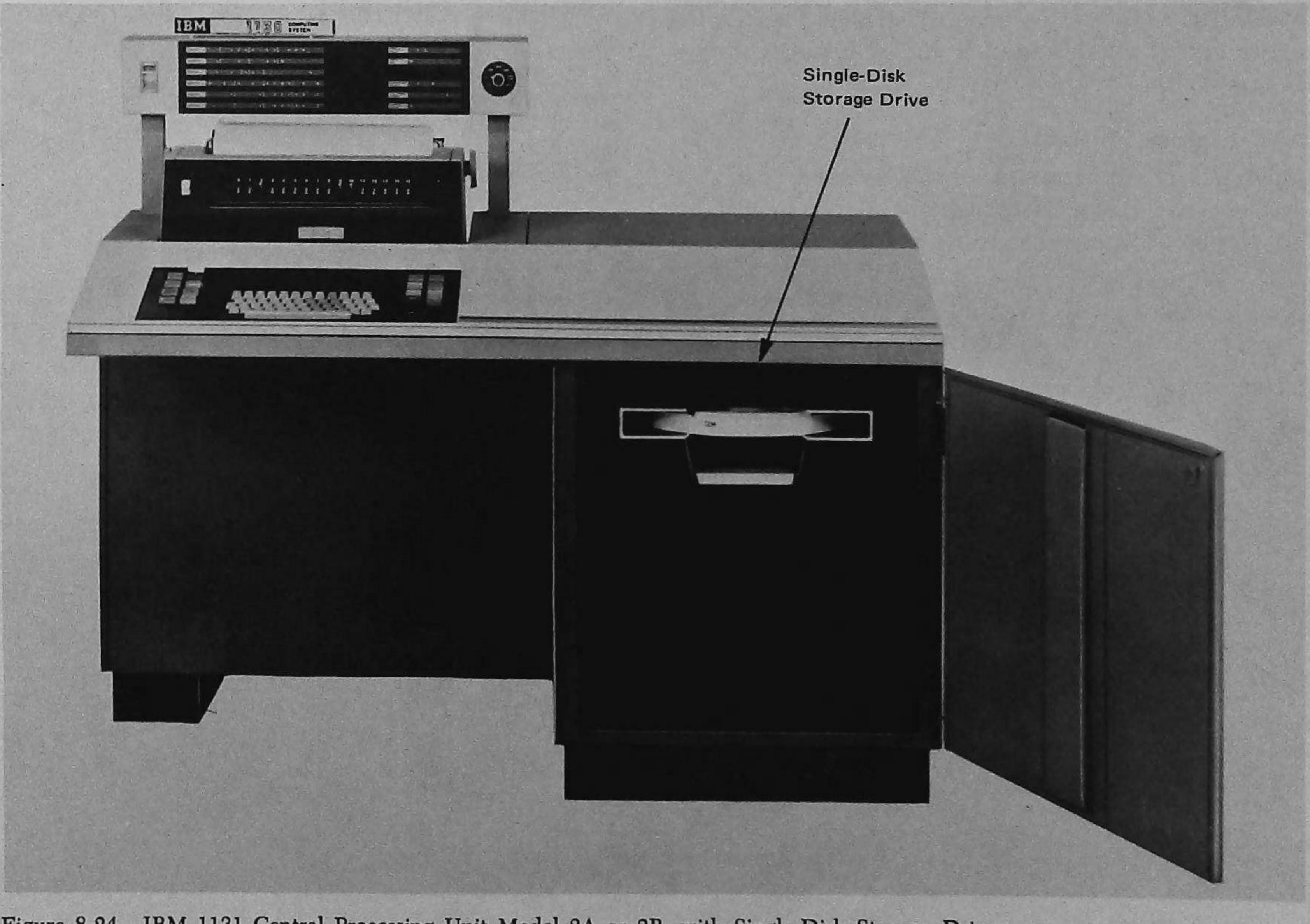


Figure 8-24. IBM 1131 Central Processing Unit Model 2A or 2B, with Single-Disk Storage Drive

arithmetic and indirect addressing and has three index registers.

Main Storage

The capacities and cycle times of main storage are model-dependent.

MODEL	CYCLE TIME (MICROSECONDS)	MAIN STORAGE (16-BIT WORDS)
1A	3.6	4,096
1B	3.6	8,192
2A	3.6	4,096
2B	3.6	8,192
2C	3.6	16,384
2D	3.6	32,768
3B	2.2	8,192
3C	2.2	16,384
3D	2.2	32,768

Additional Storage

Additional on-line storage is available for Models 2 and 3 of the 1130 through use of the single-disk storage drive (Figure 8-24). Each drive uses an IBM 2315 Disk Cartridge with a capacity of 512,000 sixteen-bit words and a data transfer rate of 28.6 microseconds per word. Models 2 and 3 can attach as many as four additional storage drives, which provides the 1130 with as much as 2,560,000 words of on-line disk storage. Because the cartridges are interchangeable, the off-line disk storage is unlimited.

Remote Terminal Operation

Operated as a remote processor terminal, the 1130 system (equipped with a synchronous communications adapter) can communicate with a System/360 over common-carrier-provided facilities or over privately owned facilities. The 1130 communicates with System/360 usually by way of a 2701 Data Adapter Unit or 2703 Transmission Control. Data communications are half-duplex and are transmitted at 600, 1,200, 2,000, or 2,400 or 4,800 bits per second, the rate depending on what communications facilities are used. Common-carrier service for these communications may be either half-duplex or duplex.

• 2770 Data Communication System

The IBM 2770 (Figure 8-24.1) is a general-purpose terminal system designed for batched-data transmission as well as for inquiry-and-response communications. It transmits and receives data through a variety of input and output devices, and can communicate with System/360 via point-to-point and multipoint communications lines.

This terminal provides for transmission of bulk data via punched cards, punched tape, magnetic tape (IBM 50 Magnetic Data Inscriber cartridges), or magnetic-ink-encoded documents. For inquiry and data-entry applications, the 2770 uses a keyboard, display station, or printer.

Available to the system in different combinations are:

IBM 50 Magnetic Data Inscriber
IBM 545 Output Punch Model 3 (nonprinting) or 4 (printing)
IBM 1017 Paper Tape Reader Model 1 or 2
IBM 1018 Paper Tape Punch
IBM 1255 Magnetic Character Reader
IBM 2213 Printer Model 1 or 2
IBM 2265 Display Station Model 2
IBM 2502 Card Reader Model A1 or A2

• Figure 8-24.1. IBM 2770 Data Communication System

The 2770 uses an IBM 2772 Multi-purpose Control Unit to attach and control the different I/O devices, and to transmit data. This unit transmits data on telephone-grade lines at 1,200, 2,000, and 2,400 bits per second in EBCDIC or USASCII, using binary synchronous communications (BSC) techniques. The 2772 can attach to a multipoint line facility with other BSC-equipped devices and systems, such as a 2780 Data Transmission Terminal, 1130 Computing System, or System/360 Model 20, using a System/360 Model 25 or larger as the control station for the multipoint network.

Among the 2770's standard features are an alphameric keyboard, two 128-character buffers, and an audible alarm (to alert the operator when intervention is required).

The 2770 system has applications in diverse areas of business, government, and private and public institutions. In a business operation for example, it may be used in management offices for data collection and for inquiry and display; in business offices for payrolls and accounting; in manufacturing plants for production and quality reports; in warehouses for shipping and receiving information and for parts inventory; and in sales offices for ordering, invoicing, and sales information.

Optional Features

Buffer Expansion doubles the capacity of the two buffers, which increases line efficiency.

EBCDIC Line Transparency enables the 2770 to send and receive control characters as data, negating their control function. This feature is required in some applications.

Multipoint Data Link Control allows more than one 2770 to be connected to a multipoint line.

Identification allows a 2770 on a switched network to identify itself as a 2770.

Keyboard Correction provides for correcting keyed data in the buffer.

Automatic Answering, for incoming calls from a central computer or another terminal, over common-carrier switched facilities.

• 2790 Data Communication System

The 2790 Data Communication System (Figure 8-24.2) is a two-way in-plant data communication and production reporting system. It provides for rapid information transfer from 2795 or 2796 Data Entry Units (located at various plant sites) to 2791 or 2793 Area Stations, which connect to a system controller and processor (Figure 8-24.3). The 2790 also provides for interrogation of a System/360.

In a typical application, the 2790 system can be used as a shop-floor control system to collect information on machine operations, work progress, stock status, material availability, and quality control. The area stations and 1035 Badge Readers can be used as a high-speed attendance-reporting system. The area stations can also be used to retrieve information stored in System/360.

The 2790 system, when attached to a System/360, can consist of various combinations of the following units:

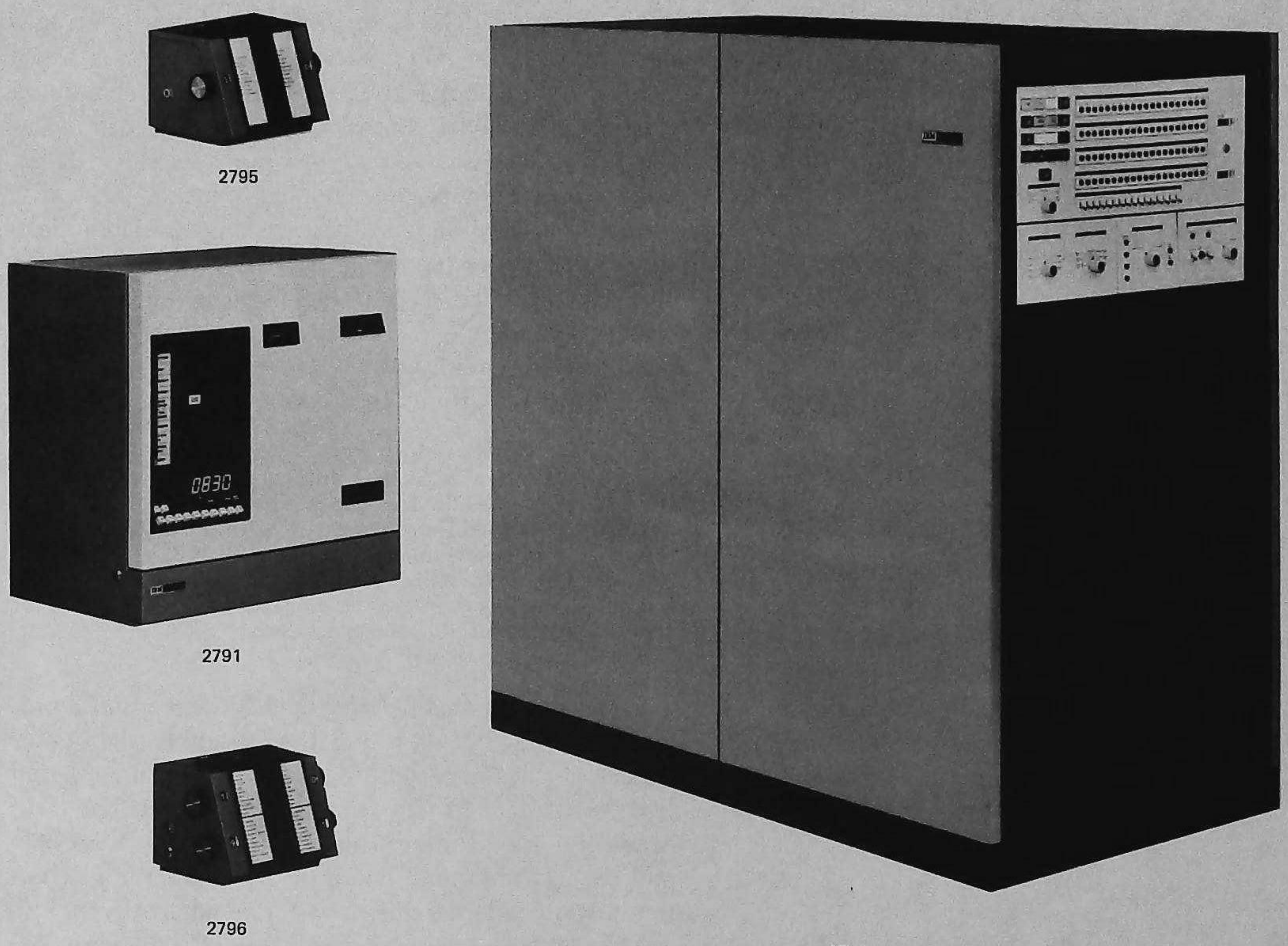
IBM 2715 Transmission Control Unit (one)
IBM 2791/2793 Area Stations (up to 100)
IBM 2795/2796 Data Entry Units (up to 32 per 2791 Model 1 or 2793, to a maximum of 1024)
IBM 1035 Badge Readers (up to three per 2791-1)
IBM 1053 Printers (one per 2791-1 or 2793)
IBM 2740 Communication Terminal (one)
Customer-provided digital devices

2715 Transmission Control Unit Models 1 and 2 provide terminal control, transaction assembly, data entry checking, message routing, transaction storage, and transfer of data to and from a System/360. The 2715 Model 1 is used for local operation with a System/360, and the 2715 Model 2 (with binary synchronous communications adapter) is used for remote operations.

The 2790 permits data entry through 2795 and 2796 Data Entry Units attached to 2791-1 or 2793 Area Stations. The 2791-1 permits data entry by punched card, employee badge, and key entry. A program-controlled display panel guides the operator in entering data, and a visual display panel permits verification of keyed data prior to transmission. (All these functions are also performed by the 2791-2).

Both the 2791-1 and 2793 can attach up to 32 data entry units and a 1053 Printer. The 2791-1, however, can also attach customer-provided digital read-in devices and up to three 1035 Badge Readers.

The 2795 and 2796 Data Entry Units are compact industrial units for reporting job and machine status and production information. Designed for use by production employees at their work location, these units transmit up to 40 characters per second to the 2791 Model 1 or 2793 Area Station by way of a two-wire line. Via the 2795, data can be entered by card, badge, and two 10-position code-selection rotary switches. Via the 2796, data can be entered by card, badge, four 10-position code-selection rotary switches, and manual entry of up to four digits.



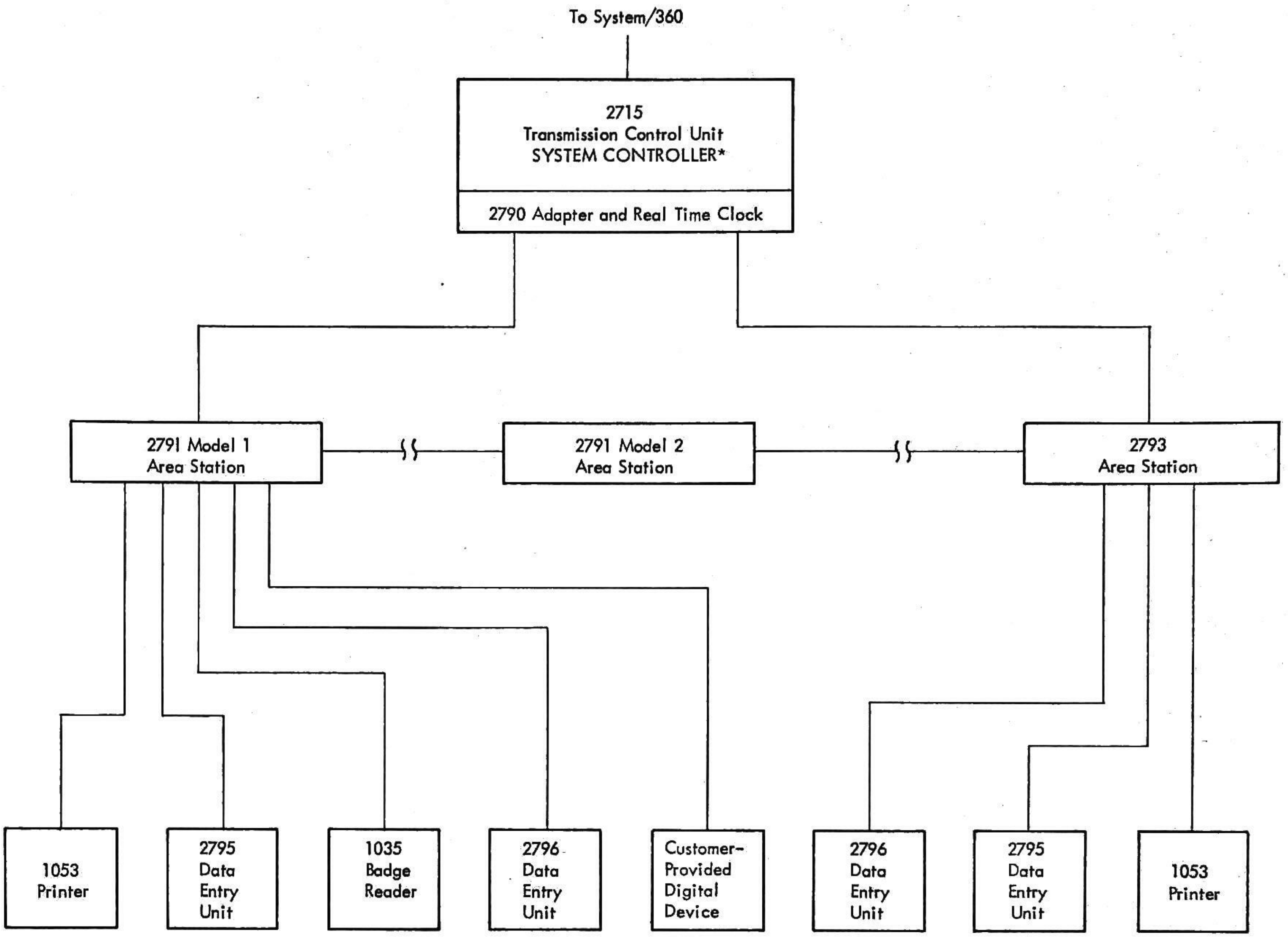
2795

2791

2796

2715

● Figure 8-24.2. Units of the IBM 2790 Data Communication System



* An 1800 Data Acquisition and Control System may be used in place of a 2715 as the system controller. In such a configuration, the 1800 (and not the System/360) would control the 2790 system.

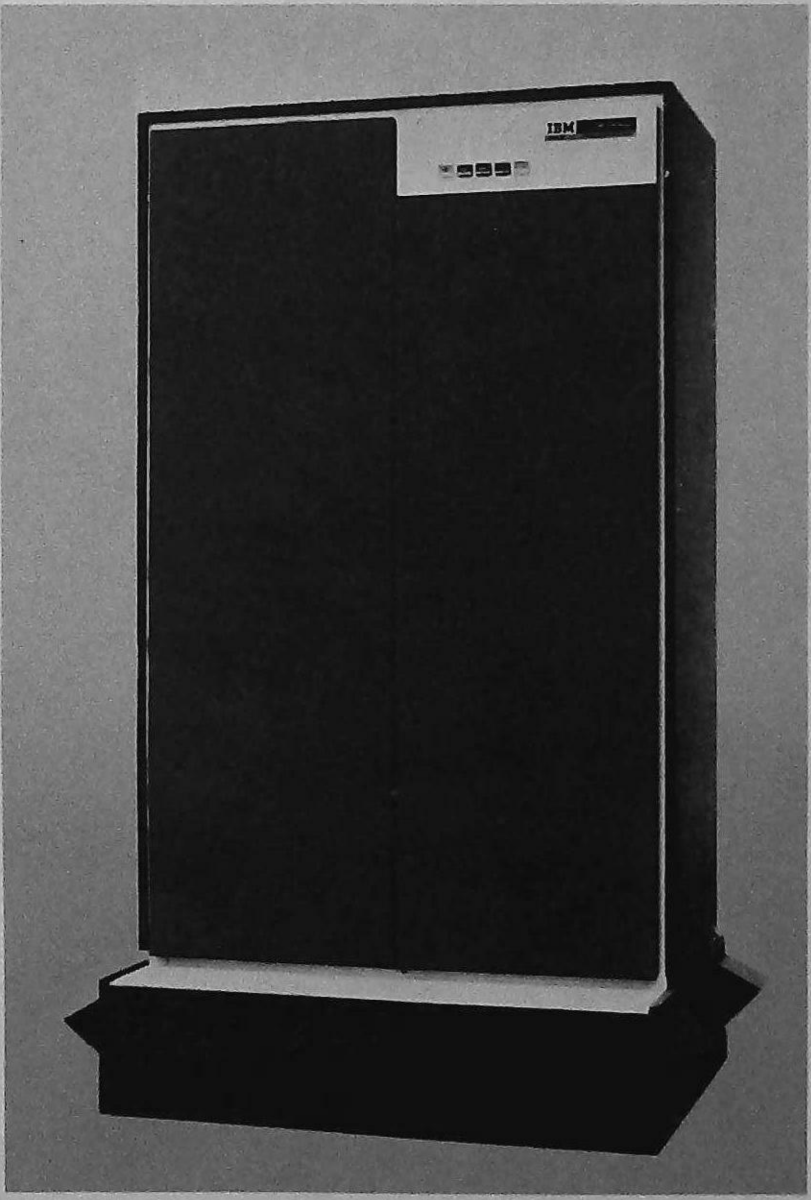
- Figure 8-24.3. A Simplified Configuration of a 2790 Data Communication System

Audio Communications Devices

7770 Audio Response Unit Model 3

The IBM 7770 Audio Response Unit Model 3 (Figure 8-25), designed for operation with System/360 exclusively, provides a spoken response to digital inquiries from telephones; IBM 1092 (in tandem with the 1093), and IBM 1093 (stand-alone) Keyboards; IBM 1001 Data Transmission Units; or similar terminals. The spoken response is composed from an American English vocabulary prerecorded in a male or female voice on a magnetic drum within the 7770. The response is transmitted over appropriate common-carrier communications facilities back to the inquiring terminal. When the 7770 is operating in conversational mode, the inquiry-response sequence may be repeated any number of times without redialing the 7770.

To make an inquiry of the 7770, the calling party enters a series of characters from his terminal. The 7770 passes these characters one by one via the multiplexer channel to the System/360, which processes the inquiry and sends a response message back, character by character, to the 7770. This response message is a series of drum word addresses that the 7770 uses to select the proper words for its spoken reply. There is no limitation on the length of the inquiry or of the response.



• Figure 8-25. IBM 7770 Audio Response Unit

The 7770 Audio Response Unit Model 3 attaches to System/360 via the multiplexer channel. Each 7770 occupies one control unit position and requires one multiplexer subchannel for each communications line. The basic 7770 handles four half-duplex, voice-grade communications lines, but this capacity can be expanded in four-line increments to 48 lines. Random inquiries on all input/output lines can be responded to simultaneously. All data sets must be provided by a common carrier.

Each 7770 comes with a 32-word vocabulary that can be expanded in 16-word increments to a maximum of 128 words. Vocabulary words may be specified by the user according to message requirements. However, lengthy words must be split and will count as two words. The vocabulary can be changed at any time by removing the drum and replacing it with another having a different vocabulary. One word of each user vocabulary must be silence.

Special Features

I/O Line Expander: Each I/O line expander feature provides for four additional input/output lines. A maximum of 11 of these features is allowed.

I/O Line Frame: This feature provides an additional frame when the number of input/output lines exceeds 16.

I/O Line Panel: An I/O line panel is required for each group of eight input/output lines or portion thereof added beyond the first eight lines. A maximum of five panels is allowed.

Additional Vocabulary Words: Increments of 16 words may be added up to the maximum of 128 words.

End of Inquiry (EOI) Disable: Allows EOI character on push-button telephones to be used as a data character instead of an EOI character.

7772 Audio Response Unit Model 3

Similar to the 7770 Audio Response Unit previously discussed, the IBM 7772 Audio Response Unit (Figure 8-26) provides a spoken reply in a female voice to inquiries from the same group of terminals. However, the two units differ in several ways.

In the 7770, the audio response comes from a vocabularly pre-recorded in analog form on a magnetic drum within the 7770 itself. In the 7772, the audio response comes from a vocabulary pre-recorded in digitally coded voice and stored in a direct access

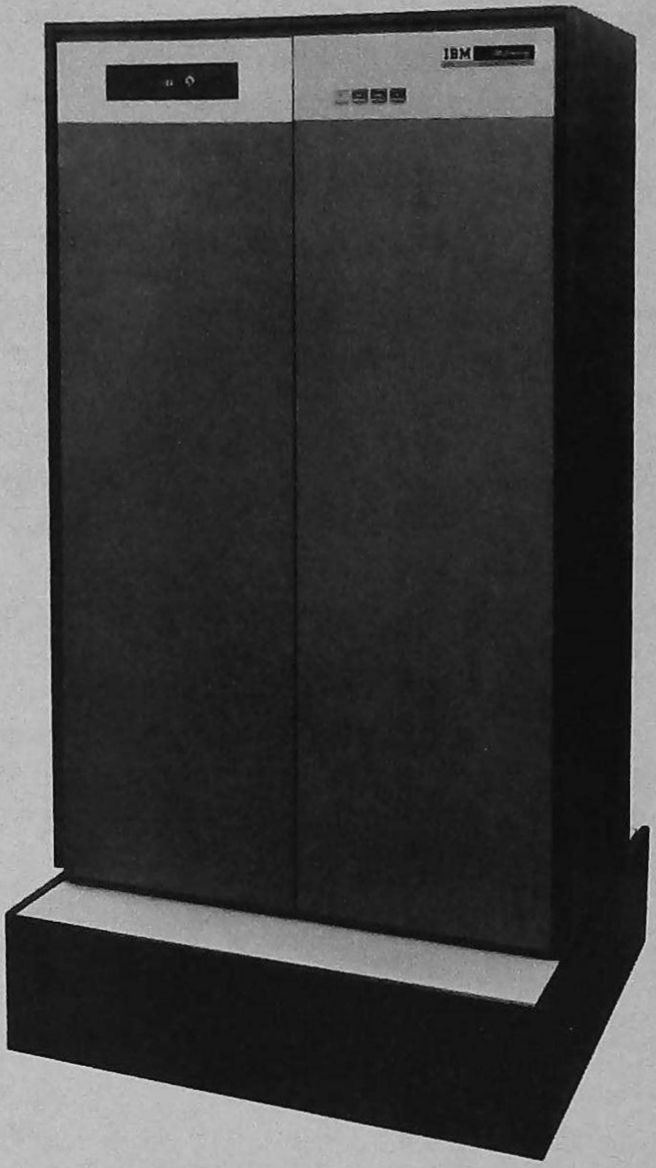


Figure 8-26. IBM 7772 Audio Response Unit

storage device. Instead of receiving a series of drum addresses from the processing unit, the 7772 receives the digitally coded voice messages, which it converts to audio. Another difference between the two units is that the 7770 offers a limited vocabulary with many I/O communications lines (four lines basic, expandable with special features to 48), whereas the 7772 offers unlimited vocabulary with a small number of lines (two lines basic, expandable with special features to a maximum of eight lines.)

The 7772 connects the communications facilities to System/360 via the multiplexer channel. The 7772 operates in half-duplex mode over common-carrier switched telephone networks, common carrier leased private line switched telephone service, and privately owned communications networks of voice-grade. Each audio response unit occupies one control unit position on the channel and requires one subchannel for each of its attached communications lines.

Special Features

End of Inquiry (EOI) Disable: Allows EOI character on push-button telephones to be used as a data character instead of an EOI character.

I/O Line Expander: Each I/O line expander feature provides two additional input/output lines to the 7772. As many as three of these features may be attached.

Additional Vocabulary Words: IBM supplies each user with a complete library of the most frequently used American English words associated with commercial and industrial applications. The entire library is available in digitally coded form on either punched cards or magnetic tape. In addition, a user may request ten additional discrete American English words without charge. When this feature is used, the user can add as many words to his library as he needs for a small cost.

Data Acquisition and Process Control Systems

Three basic System/360 configurations have been designed to satisfy the requirements for real-time data acquisitions, analysis, and process control:

1. IBM 1070 Process Communication System.
2. IBM 1800 Data Acquisition and Control System.
3. IBM 1827 Data Control Unit with IBM 1800 system devices and features.

Each of these three basic configurations can accept both analog and digital electrical signals from such devices as thermocouples, pressure transducers, flow meters, analytical instruments, and contacts. They can also provide both analog and digital electrical signals to actuators, analog controllers, annunciators, lights, and contacts.

1070 Process Communication System

The IBM 1070 Process Communication System (Figure 8-27) is a data acquisition and control system designed for two-way data communication over standard communications lines between remote process locations and a central data processing system. The 1070 system has the necessary ruggedness and compactness to allow its use in a wide variety of industrial environments. The 1070, for example, can collect and transmit data from refineries, chemical plants, paper mills, steel mills, and manufacturing areas. The 1070 equipment at each process area can be either operator-oriented or fully automatic. Except for the 1053 printer, all 1070 units can be mounted in a standard 19-inch rack.

When the 1070 is connected to System/360, the two systems form a complete management information system. With this system, management can supervise quality and production, schedule jobs to take advantage of available equipment or to meet emergency needs, and perform on-line accounting. The 1070 system connects to System/360 through the 2701 Data Adapter Unit or the 2702 or 2703 Transmission Controls. As many as twenty-six 1070 terminals may be attached to one communications line. The 1070 transmits and receives in half-duplex mode over voice- or subvoice-grade lines at 14.8 or 66.6 binary-coded-decimal characters per second (corresponding to bit rates of 134.5 or 600 bits per second), depending on which model of the 1071 is chosen. When operating at 134.5 bits per second, 1070 and 1050 systems may be mixed on the same communications line. Transmission at this rate may take place over leased common-carrier telephone lines, Western Union leased subvoice-grade service, or privately-owned communications lines. Transmission at 600 bits per second may take place over leased common-carrier or privately-owned communications facilities. All data transmitted and received are checked for validity.

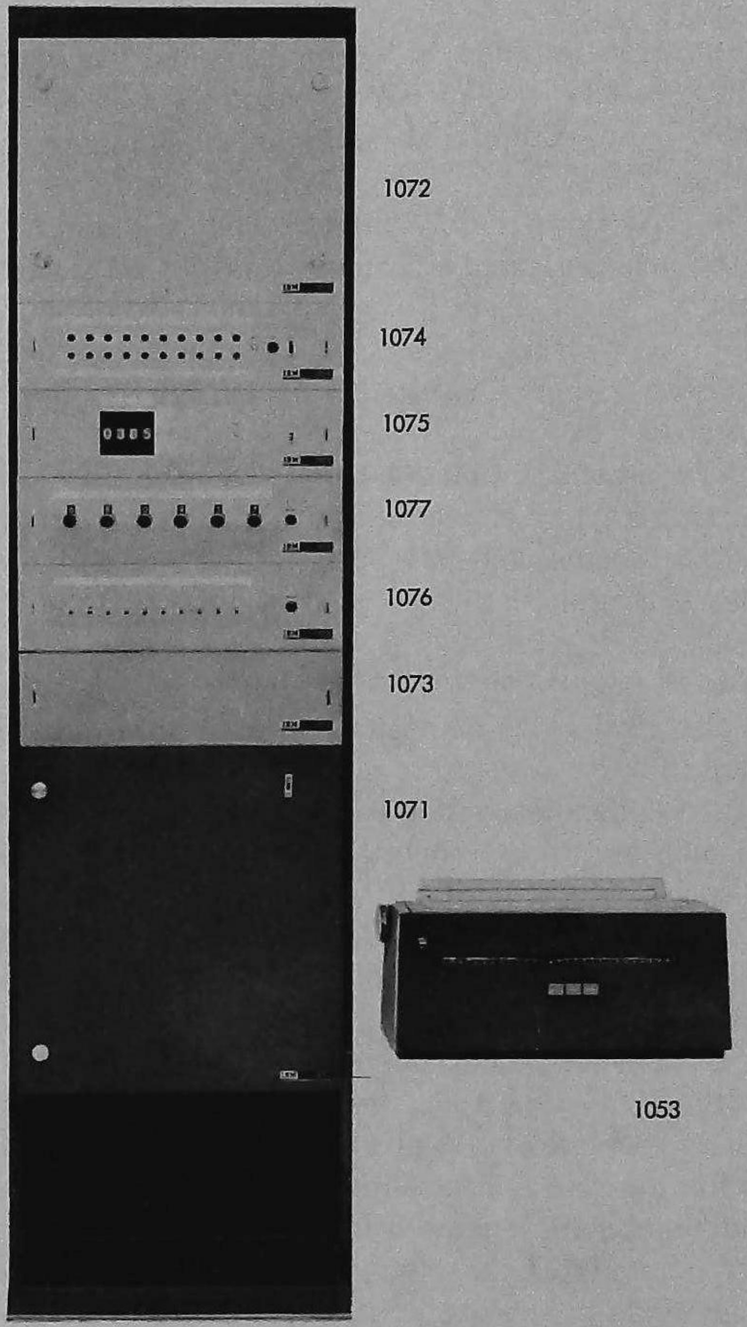


Figure 8-27. IBM 1070 Communication System

The 1070 system consists of the following units:

IBM 1071 Terminal Control (one required in each system)
IBM 1072 Terminal Multiplexer (one required in each system; up to six can be installed)
IBM 1073 Terminal Units
Process Operator Console Units
  IBM 1074 Binary Display
  IBM 1075 Decimal Display
  IBM 1076 Manual Binary Input
  IBM 1077 Manual Decimal Input
  IBM 1078 Pulse Counter
  IBM 1053 Printer

IBM 1071 Terminal Control: This unit is the control center of the 1070 terminal. All data to and from System/360 are channeled through it. The basic 1071 contains logic for addressing 50 input/output points. This capacity can be expanded to 300 points, in modules of 50. (A point is a termination for a pair of wires.) The 1071 provides contact sense, decimal, and

BCD input; in addition, it performs contact operate functions, analog-to-digital conversion (via set-point stations) and controls all operator communication units.

IBM 1072 Terminal Multiplexer: This unit can provide terminal posts and switching relays for 50 process signals.

IBM 1073 Terminal Units: These units sense and control the opening and closing of switches that operate user devices.

Process Operator Console Units: These units allow the operator at the process location to enter binary and decimal data, and to receive a binary or decimal display or a printed output.

1800 Data Acquisition and Control System

The IBM 1800 Data Acquisition and Control System (Figure 8-28) is a versatile, high-performance system designed to handle a wide variety of real-time applications such as process control, industrial testing, and high-speed data acquisition. Unlike conventional data processing equipment, the 1800 system is designed primarily to monitor and record a wide variety of data as it is generated. Each system, however, is individually tailored to meet specific system requirements. In addition, the 1800 system can be linked to System/360, either to increase the total system computing power or to form a management information system in which production-line data is used to update inventory records, perform cost accounting, or handle other general-business data processing jobs.

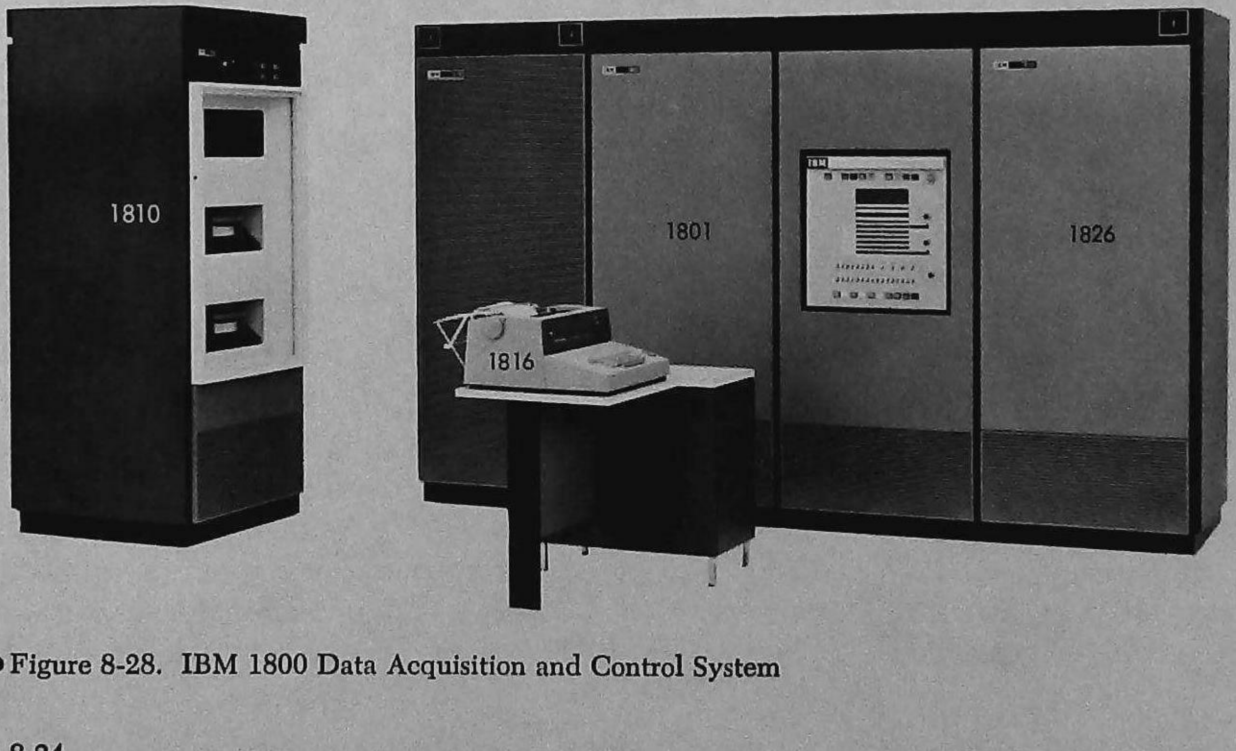
Among the continuous process control applications for which the 1800 system is suited are petroleum refining, chemical processing, steel rolling, pipeline monitoring, and power generation. The high-speed data acquisition facilities of the 1800 system are especially useful in missile pre-launch and manufacturing checkout, nuclear reactor analysis, medical-clinical analysis and monitoring, medical research, and many other applications.

1801/1802 Processor-Controller

The 1800 system is available with either the 1801 or 1802 Processor-Controller. The 1802 includes circuitry and control for connection and operation of the IBM 2401 and 2402 Magnetic Tape Units. Both the 1801 and 1802 are available in two models: the Model 1 has a main storage cycle of 4 microseconds; and the Model 2, 2 microseconds. Both models are available with four main storage capacities, ranging from 4K to 32K words (K = 1,024, and each 18-bit word has 16 data bits, one storage protection bit, and one parity bit). Main storage capacity may be expanded by adding an IBM 1803 Core Storage Unit, permitting main storage to expand to 40K, 48K, 56K, or 64K words. Systems equipped with this unit have a storage cycle time of 2.25 microseconds.

Each processor-controller provides three data channels (operating at speeds up to 500,000 words per second in burst mode with the 2-microsecond main storage), three index registers, three interval timers, a powerful instruction set, indirect addressing, twelve levels of interrupt, and a storage protection feature. As many as 12 more data channels, a selector channel, and 12 additional levels of interrupt may be added as special features. The selector channel provides the facilities for attaching up to eight 2311 Disk Storage Drives. Through the use of shared files on the 2311's, the 1800 can exchange data with System/360 or another 1800.

The 1800 system can have a variety of I/O devices for real-time process control and data processing.



• Figure 8-28. IBM 1800 Data Acquisition and Control System

Real-time process I/O devices enable the 1800 system to accept either analog or digital input signals and provide analog or digital output signals for control or display purposes.

Data processing I/O devices enable the 1800 system to perform the necessary data processing for data analysis, editing, and control purposes. These devices are also used to provide instructions for process and control room operators as well as reports for management review.

The I/O devices available to the 1800 include:

1053 Printer Model 3
1054 Paper Tape Reader Model 2
1055 Paper Tape Punch Model 2
1442 Card Read Punch Models 6 and 7
1627 Plotter Models 1 and 2
1810 Disk Storage
1816 Printer-Keyboard
2311 Disk Storage Drive with 2841 Storage Control
2401/2402 Magnetic Tape Units

Connection to System/360

Major components of the 1800 system can be connected to System/360 in three ways. A complete 1800 system, with processor-controller, can be connected to System/360 by way of a System/360 adapter or a communications adapter. When no processor-controller is involved, the 1800 system process I/O devices can be directly connected to a System/360 channel by way of an 1827 Data Control Unit.

System/360 Adapter: Functionally equivalent to the channel-to-channel adapter discussed in Section 3, this adapter permits an 1800 system to attach to a System/360 channel via the standard I/O interface. It provides half-duplex communication at rates up to 250,000 bytes per second in burst mode. Each system regards the other as an I/O device capable of requesting service on a random basis. The adapter connects to either a multiplexer or selector channel of System/360, occupying one control-unit position. It requires one data channel on the 1800 system.

Communications Adapter: This adapter permits half-duplex, synchronous communication between an 1800 and a System/360 equipped with a 2701 Data Adapter Unit (having a synchronous adapter type II), or equipped with a 2703 Transmission Control Unit. Operations using four-wire leased telephone lines can be made in duplex mode (thus reducing line turnaround delays) but message transmission must be in half-duplex mode. The communications adapter allows the 1800 system to be integrated into a large-scale control system regardless of the physical location of control systems above or below the 1800 in the control hierarchy.

1827 Data Control Unit: The 1827 Data Control Unit provides for the attachment of 1800 system analog and digital input, limit comparing, and analog and digital output features to a System/360 in the absence of an 1801/1802 Processor-Controller. With the 1827 Data Control Unit the capabilities of System/360 are extended to handle a broad range of control applications from high-speed data acquisition to supervisory control of industrial processes. The 1827 provides the standard interface that permits it to attach to a System/360 channel. When concurrent operation of 1800 system devices is desired, the 1827 is attached to a multiplexer channel or high-speed multiplexer channel; it can then communicate via as many as five subchannels. As many as 288 digital input or output points may be terminated in the 1827. In addition, the 1827 is capable of housing three basic features to interface various devices of the 1800 system: analog input basic, digital input basic, and digital and analog output basic.

System Expansion

Expansion of the digital input and output features of the 1800 is provided for by the 1826 Data Adapter Unit. This unit houses such features as the System/360 adapter, the communications adapter, and the 1800/2790 adapter (which permits the 1800 to be the "system controller" of a 2790 Data Communication System). One or more 1826's are required whenever the digital process termination points exceed 288 or whenever the combined total of digital input adapters, pulse counter adapters, and digital output adapters exceeds three. (These limitations are imposed by the 1827.) Each 1826 can house 576 process termination points or a combined total of six digital input, digital output, and pulse counter adapters. As many 1826's can be used in a system as are needed to meet a user's requirements, within the limits of the system. The system maximum for digital input is 1,024 points (or pulse counter bit positions) or eight digital input and/or pulse counter adapters. The system maximum for digital output is 2,048 points or 32 digital output adapters.

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IBM / **Technical Newsletter**

① f 2

File Number S360-00

Re: Order No. GA22-6810

This Newsletter No. GN22-0344

Date November 3, 1969

Previous Newsletter Nos. GN22-0343
(obsoleted by this TNL)

IBM System/360 System Summary

Pages to be inserted and/or removed are:

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- 3-5, 3-6
- 6-11 through 6-22
- 6-22.1 (Added)
- 6-23, 6-24
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- 8-20.1, 8-20.2, 8-20.3 (Added)
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A change to the text is indicated by a vertical line to the left of the change; where a new section has been added, the symbol ● appears to the left of the heading in text. A changed or added illustration is denoted by the symbol ● to the left of the caption.

The major changes in this Newsletter are the addition of material on the System/360 Model 195, and 2770 and 2790 Data Communication Systems.

File this cover letter at the back of the manual to provide a record of changes.

IBM Corporation, Product Publications, P.O. Box 390, Poughkeepsie, N.Y. 12602

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IBM Technical Newsletter

D fr

File Number S360-00

Re: Order GA22-6810-10

This Newsletter No. GN22-0346

Date November 15, 1969

Previous Newsletter Nos. GN22-0344

IBM System/360 System Summary:
2880 Block Multiplexer Channel Models 1 and 2

This newsletter contains information describing the IBM 2880 Block Multiplexer Channel. Insert this sheet at the end of the manual.

This material will be incorporated into the System Summary at a later date in a replacement-page technical newsletter or in a major revision.

IBM 2880 Block Multiplexer Channel Models 1 and 2

The 2880 Block Multiplexer Channel significantly increases the device-handling capabilities of System/360 Models 85 and 195 through the channel's ability to:

1. Address as many as 256 I/O devices.
2. Concurrently operate up to 64 high-speed I/O devices on a single data path.
3. Transfer data at rates as high as 3.0 million bytes per second.

The 2880, available in one- or two-channel models, can operate in either of two modes: selector channel or block multiplex. Selector channel mode is functionally equivalent to IBM 2860 Selector Channel operation and permits 2880 attachment of the 2860-attachable I/O devices supported for Models 85 and 195.

In block multiplex mode, the 2880 is similar to the 2870 Multiplexer Channel in that the 2880 can multiplex (interleave) data transferred to or from the different I/O devices which share a single data path. The two types of channel differ primarily in that the 2880 operates with much faster I/O devices, and it transfers larger quantities of data per transmission. These quantities are referred to as *blocks,* best described here as program-controlled groups of bytes, usually one or more records.

A 2880 channel transfers data at rates up to 1.5 million bytes per second, a rate higher than is possible with a 2860 Selector Channel. With the addition of the *two-byte interface* feature, a 2880 channel transfers data at rates as high as 3.0 million bytes per second.

A 2880 channel can be used in place of a 2860 channel. As many as six 2880 channels (three units of 2880 Block Multiplexer Channel Model 2) can be attached to a Model 85 or 195. With the *extended channel* feature, the total number of 2880 channels attachable to a Model 85 or 195 can be increased to 12 or 13, respectively.

For any selectable combination of channels, however, the maximum number of channel *units* is eight for a Model 85 and seven for a Model 195. (A channel unit (or "frame") contains one or more channels of the type named by the channel unit itself. A 2860 Selector Channel, for example, contains up to three selector channels.)

Summarized here are the channel attachment capabilities of Models 85 and 195.

Channel Unit	Maximum No. of Channels per Unit	Maximum No. of Channel Units per System/360		Maximum No. of Channels of Each Type, per System/360		Maximum No. of Channels per System/360	
		Model 85	Model 195	Model 85	Model 195	Model 85	Model 195
2860 Selector Channel	3	2	2	6**	6**	12 with no 2870, 13 with one or two 2870's	13 with no 2870 or with two 2870's 14 with one 2870
2870 Multiplexer Channel	1	2	2	2	2		
2880 Block Multiplexer Channel	2	6 with XC,* 3 without	7 with XC,* 3 without	12 with XC,* 6 without	13 with XC,* 6 without		

*XC = Extended Channel Feature
**Five when a system has two 2870's

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IBM / **Technical Newsletter**

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This Newsletter No. GN22-0349

Date November 21, 1969

Previous Newsletter Nos. N22-0344
N22-0346

① of 2

IBM System/360 System Summary

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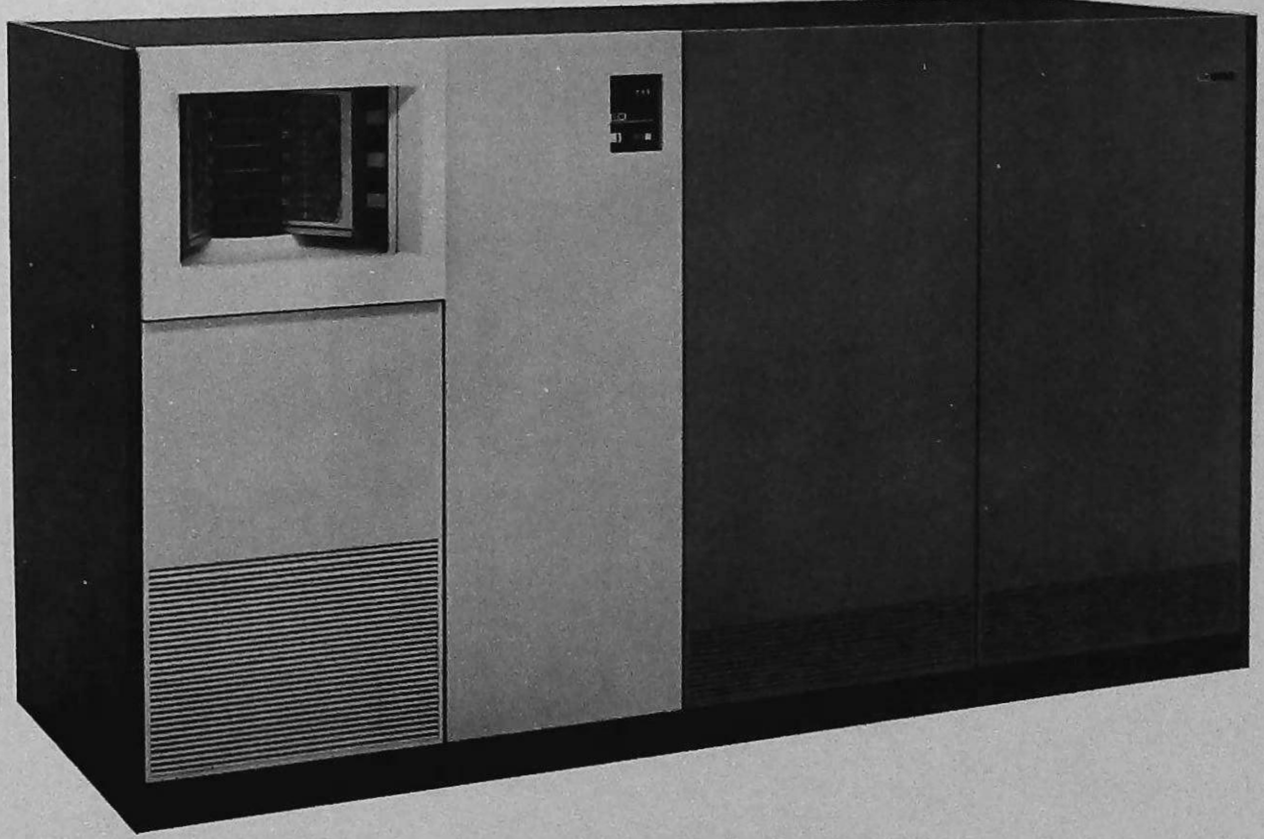
This newsletter contains information describing the IBM 2305 Fixed Head Storage Module and 2835 Storage Control.

This material will be incorporated into the System Summary at a later date in a replacement-page technical newsletter or in a major revision.

2305 Fixed Head Storage Module Models 1 and 2; 2385 Storage Control

An IBM 2835 Storage Control with one or two IBM 2305 Fixed Head Storage Modules forms an IBM 2305 Fixed Head Storage Facility. With its short access time and medium capacity, this facility provides System/360 with disk storage especially well-suited for applications such as programming systems residence and table or index storage.



IBM 2305 Fixed Head Storage Module and 2835 Storage Control

IBM Corporation, Product Publications, P.O. Box 390, Poughkeepsie, N.Y. 12602

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Two models of the 2305 facility are available:

Model 1 consists of one 2835 Model 1 and one or two 2305 Model 1 modules.

Model 2 consists of one 2835 Model 2 and one or two 2305 Model 2 modules.

The speed and capacities of the 2305 facilities are:

	Model 1	*Model 2*
Storage capacity (rounded, megabytes)	5.4 or 10.8	11.2 or 22.4
Average access time (milliseconds)	2.5	5.0
Data transfer rate (megabytes per second)	3.0	1.5

Both models of the 2305 facility attach to System/360 via the 2880 Block Multiplexer Channel. The Model 1 facility, having a data transfer rate of 3.0 million bytes per second, requires that the 2880 be equipped with the two-byte interface feature.

2305 Fixed Head Storage Module

Each 2305 module has six 14-inch oxide-coated disks permanently mounted within the module. Each module uses read/write heads having one or two read/write elements per track

The primary characteristics of the 2305 modules are:

	Model 1	*Model 2*
Number of read/write elements per track	2	1
Number of addressable tracks	384	768
Number of spare tracks	48	96
Bytes per module	5,428,224	11,258,880
Rotation time (milliseconds)	10	10
Access time, maximum (milliseconds)	5.1	10.25
Access time, average (milliseconds)	2.5	5.0
Data transfer rate (megabytes per second)	3.0	1.5

2835 Storage Control

The 2835 interprets and executes all control orders received from the 2880 channel. In addition, it provides the 2305 facility with error detection and correction capabilities by adding correction codes to each record. These codes are used to detect single-burst errors of up to 470 bits and to correct single-burst errors of up to 11 bits.

Related to these capabilities are two methods for verification of data:

Full Read-Back Check: All just-written data is read back into main storage and compared with the original data.

Correction Code Check: The 2835 performs a non-comparative check of data validity, using the correction codes.

The 2835 standard features include:

Command Retry procedure can cause a command (a channel instruction) to be retried without requiring an I/O interruption.

Vary Sensing command assists in recovery of data when an uncorrectable data check is encountered.

Rotational Position Sensing contributes to increased channel availability by freeing the channel during most of the time that another track record is being sought.

Multiple Requesting permits queuing as many as 16 record requests within the 2305 facility.

An optional feature, the *two-channel switch,* permits two channels (of one System/360 or of two separate ones) to have access to the 2305 facility.

IBM Technical Newsletter

① 1/2

File Number S360-00

Re: Order No. GA22-6810-10

This Newsletter No. GN22-0347

Date February 13, 1970

Previous Newsletter Nos.
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GN22-0343 (obsoleted
by GN22-0344)

IBM SYSTEM/360 SYSTEM SUMMARY

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This Technical Newsletter provides replacement pages for the subject publication. Pages to be inserted and/or removed are:

3-5, 3-6
6-11, 6-12
6-23, 6-24

A change to the text is indicated by a vertical line to the left of the change. A changed illustration is denoted by the symbol ● to the left of the caption.

Summary of Amendments

This Newsletter adds information on the System/360 Model 65 Multiprocessing System.

File this cover letter at the back of the manual to provide a record of changes.

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IBM Technical Newsletter

File No. S360-00

Base Publ. No. GA22-6810-10

This Newsletter No. GN22-0386

Date April 12, 1971

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GN22-0343 (Obsoleted by GN22-0344)
GN22-0344
GN22-0346
GN22-0347
GN22-0349

IBM System/360 System Summary

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This newsletter contains information describing the IBM System/360 Model 22. Insert this sheet at the end of the manual.

This material will be incorporated into the System Summary at a later date in a replacement-page technical newsletter or in a major revision.

SYSTEM/360 MODEL 22

The System/360 Model 22 has the power and capabilities to meet a wide variety of scientific and commercial needs at a relatively low cost. Providing either 24K (24,576) bytes or 32K (32,768) bytes of main storage, this model has a selector channel and byte multiplexer channel that allow the attachment of a wide variety of I/O devices. Other features, both standard and optional, further enhance the capabilities of the Model 22.

Standard Features

Standard or commerical instruction set
Byte multiplexer channel
Selector channel

Optional Features

Scientific or universal instruction set
External interrupt
Interval timer
Store protection
Integrated 1052 attachment

System Components

Central Processing Unit: IBM 2022 Processing Unit

Basic Machine Cycle Time: 0.75 microsecond (750 nanoseconds).

Instructions Sets: Either the standard or commerical instruction set is provided with the Model 22. Either set can be replaced by the scientific or universal instruction set.

External Interruption: The external interrupt feature provides six external interruption lines for requesting a response from the Model 22 and for identifying the request.

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Main Storage: Part of 2022 Processing Unit

Storage Sizes:

Capacity (Bytes)	*Model*
24,576	DC
32,768	E

Storage Cycle Time: 1.5 microseconds.

Storage Access Width: One byte.

Channels: Part of 2022 Processing Unit

Byte Multiplexer Channel: The byte multiplexer channel provides 96 subchannels and eight control-unit positions.

Selector Channel: The selector channel, which has a data rate of 170,000 bytes per second, uses a microprogram interruption to control data transfers.

Interchannel Connection: The Model 22 can communicate with other models of System/360 by the direct connection of channels, but only if the other model has a channel-to-channel adapter. The adapter requires the use of one control-unit position on each of the two channels.

Programming Support

DOS is the primary programming support for the Model 22. Other existing System/360 applications and programming systems support can be used by the Model 22 within the limitations of storage capacity, channel capability, and CPU features.

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Technical Newsletter

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Base Publication No.	GA22-6810-10
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GN22-0347 (Obsoleted by this TNL)
GN22-0349 (Obsoleted by this TNL)
GN22-0386 (Obsoleted by this TNL)

IBM System/360 System Summary

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This Technical Newsletter provides replacement pages for the subject publication. Pages to be replaced are:

Contents
2-7 through 2-9
3-5 (3-6 deleted)
6-1 through 6-23
(6-24 deleted)
7-1 through 7-11
(7-12 deleted)
8-1, 8-2
Index

All pages to which a change was made carry a revision notice in the upper margin and an updated page date. Any significant technical change (revision, addition, or deletion) is indicated by a vertical line to the left of the change.

Summary of Amendments

This technical newsletter updates the channel information, the System/360 Models Section, the Direct Access Devices subsection, and the I/O and terminal attachment data (Figures 7-1 and 8-1).

Note: *Please file this cover letter at the back of the manual to provide a record of changes.*

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